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# GEO-EAS (Geostatistical Environmental Assessment Software) User's Guide

Computer Sciences Corp., Las Vegas, NV

Prepared for

Environmental Monitoring Systems Lab.
Las Vegas, NV

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This report describes how to install and use the GEO-EAS (Geostatistical Environmental Assessment Software) software package on an IBM-PC compatible computer system. A detailed example is provided showing how to use the software to conduct a geostatistical analysis of a data set.

Thirteen Geo-EAS programs are documented. The principal functions of the package are the production of 2-dimensional grids and contour maps of interpolated (kriged) estimates from sample data. Other functions include data preparation, data maps, univariate statistics, scatter plots/linear regression, and variogram computation and model fitting. Extensive use of screen graphics such as maps, histograms, scatter plots and variograms help the user search for patterns, correlations, and problems in a data set. Data maps, contour maps, and scatter plots can be plotted on an HP compatible pen plotter. Individual programs can be run independently; the statistics and graphics routines may prove useful even when a full geostatistical study is not appropriate. For ease of use, the programs are controlled interactively through screen menus, and use simple ASCII data files.

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# GEO-EAS

# (GEOSTATISTICAL ENVIRONMENTAL ASSESSMENT SOFTWARE)

# USER'S GUIDE

by

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This report describes how to install and use the Geo-EAS (Geostatistical Environmental Assessment Software) software package on an IBM-PC compatible computer system. A detailed example is provided showing how to use the software to conduct a geostatistical analysis of a data set.

Thirteen Geo-EAS programs are documented. The principal functions of the package are the production of 2-dimensional grids and contour maps of interpolated (kriged) estimates from sample data. Other functions include data preparation, data maps, univariate statistics, scatter plots/linear regression, and variogram computation and model fitting. Extensive use of screen graphics such as maps, histograms, scatter plots and variograms help the user search for patterns, correlations, and problems in a data set. Data maps, contour maps, and scatter plots can be plotted on an HP compatible pen plotter. Individual programs can be run independently; the statistics and graphics routines may prove useful even when a full geostatistical study is not appropriate. For ease of use, the programs are controlled interactively through screen menus, and use simple ASCII data files.

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## GLOSSARY OF GEOSTATISTICAL TERMS

**Anisotropy** - In geostatistics, the situation where a variogram exhibits a longer range (i.e., better correlation) in one direction than another.

**Block Kriging** - Estimating the value of a block from a set of nearby sample values using kriging. In Geo-EAS, the block area is approximated by a 2x2, 3x3, or 4x4 array of points centered on each specified grid node.

**Covariance** - A statistical measure of the correlation between two variables. In geostatistics, covariance is usually treated as the simple inverse of the variogram, computed as the overall sample variance minus the variogram value. These covariance values, rather than variogram values, are actually used in the Geo-EAS kriging matrix equations for greater computational efficiency.

**Cross Validation** - A technique for testing the validity of a variogram model by kriging each sampled location with all of the other samples in the search neighborhood, and comparing the estimates with the true sample values. Interpretation of results, however, can often be difficult. Unusually large differences between estimated and true values may indicate the presence of "spatial outliers", or points which do not seem to belong with their surroundings.

**Discretization** - In kriging, the process of approximating the area of a block by a finite array of points.

**Exponential Model** - A function frequently used when fitting mathematical models to experimental variograms, often in combination with a nugget model.

**Gaussian Model** - A function frequently used when fitting mathematical models to experimental variograms, often in combination with a nugget model.

## Glossary (Continued)

**Geostatistics** - A methodology for the analysis of spatially correlated data. The characteristic feature is the use of variograms or related techniques to quantify and model the spatial correlation structure. Also includes the various techniques such as kriging, which utilize spatial correlation models.

**Kriging** - A weighted-moving-average interpolation method where the set of weights assigned to samples minimizes the estimation variance, which is computed as a function of the variogram model and locations of the samples relative to each other, and to the point or block being estimated.

**Kriging Standard Deviation** - The standard error of estimation computed for a kriged estimate. By definition, kriging is the weighted linear estimate with the particular set of weights which minimizes the computed estimation variance (standard error squared). The relationship of the kriging standard deviation to the actual error of estimation is very dependent on the variogram model used and the validity of the underlying assumptions - therefore kriging standard deviations should be interpreted with caution.

**Lag** - A distance class interval used for variogram computation.

**Linear Model** - A function frequently used when fitting mathematical models to experimental variograms, often in combination with a nugget model.

**Madogram** - A plot of mean absolute difference of paired sample measurements as a function of distance and direction. Madograms are not true variograms, and generally should not be used in kriging. If used, the kriged estimates might be "reasonable", but the kriging standard deviations will be meaningless.

**Nested Variogram Model** - A model which is the sum of two or more component models such as nugget, spherical, etc. Adding a nugget component to one of the other models is the most common nested model, but more complex combinations are occasionally used.

**Non-ergodic Variogram** - A variogram computed by subtracting lag covariances from the sample variance. This approach compensates for cases where in directional variograms, the mean of the, say, west members of the sample pairs is not the same as the mean of the east members. "Non-ergodic" is a rather obscure term referring to the fact that some probabilistic assumptions underlying the variogram computation are no longer necessary. Non-ergodic variograms may be modeled and used in kriging in the same way as ordinary variograms.

**Nugget Model** - A constant variance model most often used in combination with one or more other functions when fitting mathematical models to experimental variograms.

**Octant Search** - In Geo-EAS, the kriging search neighborhood ellipse may be divided into eight equal-angle sectors, which may have minimum and maximum numbers of samples specified. A limit on the number of consecutive empty sectors may also be specified. When the specified criteria are not satisfied for a particular point or block then the kriged estimate is not produced.

**Ordinary Kriging** - A variety of kriging which assumes that local means are not necessarily closely related to the population mean, and which therefore uses only the samples in the local neighborhood for the estimate. Ordinary kriging is the most commonly used method for environmental situations.

**Point Kriging** - Estimating the value of a point from a set of nearby sample values using kriging. The kriged estimate for a point will usually be quite similar to the kriged estimate for a relatively small block centered on the point, but the computed kriging standard deviation will be higher. When a kriged point happens to coincide with a sampled location, the kriged estimate will equal the sample value.

**Quadrant Search** - In Geo-EAS, the kriging search neighborhood ellipse may be divided into four equal-angle sectors, which may have minimum and maximum numbers of samples specified. A limit on the number of consecutive empty sectors may also be specified. When the specified criteria are not satisfied for a particular point or block then the kriged estimate is not produced.

**Range** - For a spherical model, the distance at which the model reaches its maximum value, or sill. For the exponential and gaussian models, which approach the sill asymptotically, Geo-EAS uses range to mean the "practical", or "effective" range, where the function reaches approximately 95% of the maximum. The nugget model effectively has a sill with a range of zero; the linear model uses "sill/range" merely to define the slope.

**Relative Variogram** A variogram in which the ordinary variogram value for each lag has been divided by the square of the mean of the sample values used in computing the lag. This is sometimes useful when a "proportional effect" is present; i.e., when areas of higher than average concentration also have higher than average variance. When relative variogram models are used in kriging, the resulting kriging standard deviations represent decimal fractions of the estimated values.

## Glossary (Continued)

**Search Neighborhood** - In Geo-EAS, an elliptical area centered on a point or block being kriged. Only samples within the ellipse will be used for kriging. When the next point is kriged, the ellipse will be re-centered, and a different (perhaps) set of samples will be used.

**Semi-variogram** - Identical to the term "variogram" as defined in Geo-EAS. There is disagreement in the geostatistical literature as to which term should be used. Geo-EAS uses "variogram" for simplicity.

**Sill** - The upper limit of any variogram model which has such a limit, i.e., which tends to "level off" at large distances. In Geo-EAS, the spherical, gaussian, exponential, and nugget models have sills. For the linear model, "sill/range" is used merely to define the slope.

**Simple Kriging** - A variety of kriging which assumes that local means are relatively constant and equal to the population mean, which is well-known. The population mean is used as a factor in each local estimate, along with the samples in the local neighborhood. This is not usually the most appropriate method for environmental situations.

**Spherical Model** - A function frequently used when fitting mathematical models to experimental variograms, often in combination with a nugget model.

**Variogram** - A plot of the variance (one-half the mean squared difference) of paired sample measurements as a function of the distance (and optionally of the direction) between samples. Typically, all possible sample pairs are examined, and grouped into classes (lags) of approximately equal distance and direction. Variograms provide a means of quantifying the commonly observed relationship that samples close together will tend to have more similar values than samples far apart.

## ABBREVIATIONS

Throughout this manual, keyboard keys are expressed in lower case and enclosed in angle brackets. The following is a list of commonly used keys:

| SYMBOL | DESCRIPTION |
|---|---|
| <enter> | - enter key |
| <esc> | - escape key |
| <a>, ..., <z> | - alphanumeric keys |
| <0>, ..., <9> | - numeric keys |
| <ins>, <del> | - insert, delete keys |
| <home>, <end>, <pg up>, <pg dn> | - page control keys |
| <left>, <right>, <up>, <down> | - cursor control keys |
| <backspace> | - backspace key |
| <ctrl>, <alt>, <shift><br><caps lock>, <num lock>, <scroll lock> | - special purpose keys |

## ACKNOWLEDGEMENTS

This document is intended to serve both as an introduction to the Geo-EAS software package (see Software Ordering Information, Section 1.3), and as a reference manual. The Geo-EAS software itself is, of course, the primary product, and deserves a brief description of how it came about, along with an acknowledgement of the many people who contributed to its development.

The ongoing USEPA research program in environmental geostatistics at the Environmental Monitoring Systems Laboratory - Las Vegas (EMSL-LV) was begun about six years ago, largely through the efforts of George Flatman. As an incidental result of various research projects conducted under Cooperative Agreements with Stanford University, the University of Wyoming, and the University of Arizona, EMSL-LV acquired a miscelleneous collection of public domain geostatistical and statistical software.

In the summer of 1986, as the authors were designing a relatively straightforward consolidation of this software involving standardization of parameters and file structures, we were approached by Andre Journel and Roland Froidevaux of Stanford, who enthusiastically demonstrated a prototype of a 'user friendly' PC-based geostatistical package written by Froidevaux in Turbo Pascal, and recommended that we consider a similar approach. Although this would considerably increase the scope of the effort, the potential 'technology transfer' value was very high, and we decided to proceed.

A team consisting of Nancy Fisher of the Computer Sciences Corporation (CSC), Journel, Froidevaux, Flatman, and the authors, defined the philosophy and sketched the initial design for the system, drawing heavily on Froidevaux's example for the 'look and feel' of the menu-driven user interface and integrated graphics. It was decided, among other things, to program in FORTRAN, to try to stay entirely in the public domain, to use a simple ASCII data file structure, and to target a hypothetical user with an AT and EGA graphics.

Suleiman Lalani of CSC provided a major boost to the software development by contributing the screen management software used throughout the package. Chris Nisi of CSC coded the Dataprep and Trans programs. Melissa Robinson, also of CSC, converted public domain graphics routines from the National Center for Atmospheric Research (NCAR) and used them to develop the Xygraph, and Postplot programs. David Gonzales of EMSL-LV wrote routines for identifying PC hardware configurations, and assisted with the metacode device drivers.

We gratefully acknowledge the advice and encouragement provided by Andre Journel throughout the development process. We are also indebted to the many people who provided constructive reviews of the software and user's guide, including: Randal Barnes of the University of Minnesota, Dave Grundy of the U.S. Geological Survey, Stan Miller of the University of Idaho, Brent Huntsman of Terran Corporation, John Rogers of Westat, and William P. Smith and James C. Baker of the USEPA.

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## SECTION 1

## INTRODUCTION

### 1.1 OVERVIEW

Geo-EAS (Geostatistical Environmental Assessment Software) is a collection of interactive software tools for performing two-dimensional geostatistical analyses of spatially distributed data. Programs are provided for data file management, data transformations, univariate statistics, variogram analysis, cross validation, kriging, contour mapping, post plots, and line/scatter graphs. Features such as hierarchical menus, informative messages, full-screen data entry, parameter files, and graphical displays are used to provide a high degree of interactivity, and an intimate view of results. Users may easily alter parameters and re-calculate results or reproduce graphs, providing a "what if" analysis capability.

Geostatistical methods are useful for site assessment and monitoring situations where data are collected on a spatial network of sampling locations, and are particularly suited to cases where contour maps of pollutant concentration (or other variables) are desired. Examples of environmental applications include lead and cadmium concentrations in soils surrounding smelter sites, outdoor atmospheric $NO_2$ concentrations in metropolitan areas, and regional sulfate deposition in rainfall. Kriging is a weighted moving average method used to interpolate values from a sample data set onto a grid of points for contouring. The kriging weights are computed from a variogram, which measures the degree of correlation among sample values in the area as a function of the distance and direction between samples.

Kriging has a number of advantages over most other interpolation methods:

**Smoothing** - Kriging smoothes, or regresses, estimates based on the proportion of total sample variance accounted for by random "noise". The noisier the data set, the less individual samples represent their immediate vicinity, and the more they are smoothed.

**Declustering** - The kriging weight assigned to a sample is lowered to the degree that its information is duplicated by nearby, highly correlated samples. This helps mitigate the impact of oversampling "hot spots".

**Anisotropy** - When samples are more highly correlated in a particular direction, kriging weights will be greater for samples in that direction.

**Precision** - Given a variogram representative of the area to be estimated, kriging will compute the most precise estimates possible from the available data. In practice, this is only approximated, as the variogram must itself be estimated from the available data.

Estimation of the variogram from sample data is a critical part of a geostatistical study. The procedure involves interpretation and judgment, and often requires a large number of "trial and error" computer runs. The lack of inexpensive, easy-to-use software has prevented many people from acquiring the experience necessary to use geostatistical methods effectively. This software is designed to make it easy for the novice to begin using geostatistical methods and to learn by doing, as well as to provide sufficient power and flexibility for the experienced user to solve real-world problems.

## 1.2 EQUIPMENT REQUIREMENTS

This system was designed to run under DOS (Disk Operating System) on an IBM PC, XT, AT, PS2, or compatible computer. Graphics capability is not required, but is highly recommended, as most programs will produce graphics output. Graphics support is provided for the Hercules graphics card, the Color Graphics Adapter (CGA), and the Enhanced Graphics Adapter (EGA). At least 512 kilobytes (Kb) of random access memory (RAM) is required, but 640 Kb is recommended. An arithmetic co-processor chip is strongly recommended due to the computationally intensive nature of the programs, but is not required for use. Programs may be run from floppy diskette, however, a fixed disk is required to use the programs from the system menu. The system storage requirement is approximately three megabytes. For hardcopy of results, a graphics printer (IBM graphics compatible) is required. Support is provided for plotters which accept HPGL plotting commands.

## 1.3 SOFTWARE AVAILABILITY

The Geo-EAS software in its executable form is entirely in the public domain, and can be obtained by sending the appropriate number of diskettes (PREFORMATTED, PLEASE!) to the following address:

Evan J. Englund (Geo-EAS)
USEPA EMSL-LV, EAD
P.O. Box 93478
Las Vegas, NV 89193-3478

The executable files and example data sets take approximately 3 megabytes of storage, and require the following number of diskettes, depending on the type:

| Type | | Number |
|---|---|---|
| 5 1/4" | 1.2MB | 3 |
| 5 1/4" | 360KB | 9 |
| 3 1/2" | 1.44MB | 3 |
| 3 1/2" | 722KB | 6 |

The source code is written in FORTRAN 77 for the Microsoft (Microsoft Corporation, Redmond WA) FORTRAN compiler (version 4.01). With the exception of slightly modified proprietary Graflib (Sutra Software, Sugarland TX) subroutines used for generating screen graphics, the source code is also in the public domain. For further information on the source code and programmer documentation, contact:

Geo-EAS
Computer Sciences Corporation
P.O. Box 93478
Las Vegas, NV 89193-3478

## 1.4 USER PROFILE

To use this system, you should have some familiarity with personal computers, and DOS (Disk Operating System). You should understand basic DOS commands such as DIR (Directory), CD (Change Directory), and how to insert and use diskettes. For more information on these topics, consult a DOS use's manual. It is assumed that you have a working knowledge of Geostatistics, and that you understand the basic Geostatistical concepts. For a list of references on the subject of geostatistics, refer to Appendix A, References.

# SECTION 2

# SYSTEM SUMMARY

## 2.1 INSTALLING THE SYSTEM

### 2.1.1 The Distribution Diskettes

The distribution diskettes contain the files needed for system operation. Some programs require the presence of a character font file in order to execute properly. Below is a list of the files which are included on the distribution diskettes:

Program files:

| | |
|---|---|
| GEOEAS.EXE | - the system menu program |
| DATAPREP.EXE | - data management utilities |
| TRANS.EXE | - data transformations |
| STAT1.EXE | - basic univariate descriptive statistics |
| SCATTER.EXE | - scatter plots, linear regression |
| PREVAR.EXE | - pair comparison computations for VARIO |
| VARIO.EXE | - variogram analysis and modeling |
| XVALID.EXE | - cross validation of parameters for KRIGE |
| KRIGE.EXE | - 2 dimensional kriging |
| CONREC.EXE | - contouring of gridded data |
| POSTPLOT.EXE | - graphs of sample locations and values |
| XYGRAPH.EXE | - 2 dimensional line/scatter graphs |
| VIEW.EXE | - plots graph files on the screen |
| HPPLOT.EXE | - creates plotter files from graphic metafiles |

Miscellaneous files:

| | |
|---|---|
| HERSHY.BAR | - character font file (required by CONREC, POSTPLOT, XYGRAPH, VIEW, and HPPLOT.) |
| EXAMPLE.DAT | - example data file |
| EXAMPLE.GRD | - example gridded data file (for CONREC) |
| METACODE.MET | - example graph file |
| HPGL.PLT | - example plotter instruction file |
| HPSETUP.BAT | - commands to set up plotter communications |
| READ.ME | - additional "last-minute" information |

### 2.1.2 Hard Disk Installation

To install the system on a fixed disk, a subdirectory should first be created (for example, GEOEAS). For information about creating subdirectories, refer to the DOS reference manual. All files on the distribution diskettes should be copied into the subdirectory. For more information on how to copy files from a diskette into a subdirectory, refer to your DOS user's manual. Approximately three megabytes (3 million bytes) of storage is required. If insufficient disk space is available for all files to reside together on fixed disk, programs must be initiated from DOS and the system menu (GEOEAS.EXE) may not be used.

### 2.1.3 Using the Programs on Floppy Diskette

The fact that all programs and support files cannot reside on one floppy diskette has several implications. Since the system menu program requires that all files be present on the same disk and subdirectory, the system menu may not be used to run the programs; they must be initiated from DOS. Since several programs require the presence of HERSHY.BAR to operate correctly, it is important that both the executable file and HERSHY.BAR reside on the same diskette. Unfortunately, the size of the executable files for programs XYGRAPH, POSTPLOT, and CONREC are too large to fit on the same 360 kilobyte diskette with HERSHY.BAR. This means that if you only have 360 kilobyte disk drives (and no fixed disk) you will not be able to use these programs. A separate working diskette may be prepared for each program, subject to the restrictions mentioned above.

## 2.2 INITIATING THE SYSTEM

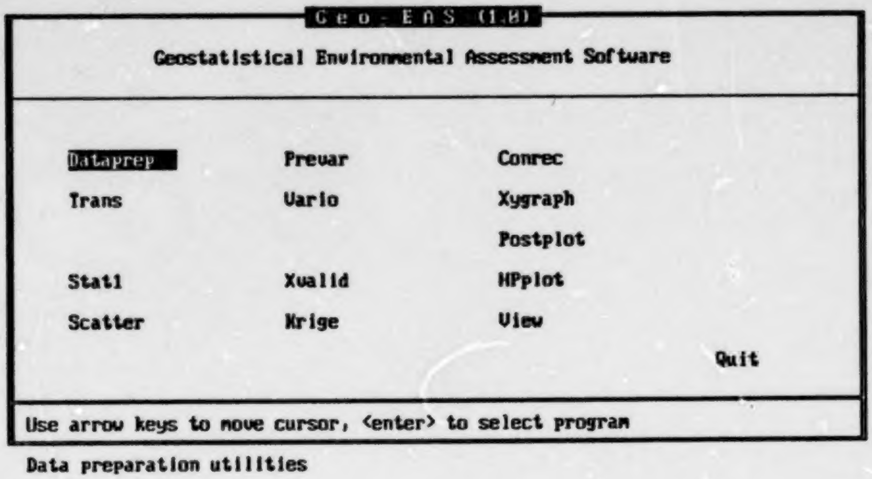
### 2.2.1 Using the Geo-EAS System Menu

A program has been provided on the distribution diskettes which allows access to all programs from a common menu, called the System Menu. This file is named GEOEAS.EXE. Use of the system menu program requires that all program and support files reside on the same disk and subdirectory (e.g. C:\GEOEAS). To start the system menu program, type: GEOEAS <enter>.

A screen will be presented with the program names as in Figure 2-1. A highlighted box (cursor bar) will appear on the screen. The cursor bar may be moved around the screen by using the <left>, <right>, <up>, or <down> keys. When the cursor bar is positioned over a program name, a short description of the program will appear at the bottom of the screen. To initiate the described program, press <enter>.

*** Note ***

The Geo-EAS system must have use of all available memory. No memory-resident programs such as SideKick may be loaded, or the system menu program will not be able to load some programs. If an error message occurs when using the system menu, try to initiate the desired program from DOS. If the program will not load correctly, you must disable the loading of such memory-resident programs, and re-start the computer. Programs in which this is likely to happen are: Vario, Stat1, Xygraph, and Postplot.


Geo-EAS (1.0)
Geostatistical Environmental Assessment Software
Dataprep
Prevar
Conrec
Trans
Vario
Xygraph
Postplot
Stat1
Xvalid
HPplot
Scatter
Krige
View
Quit

Use arrow keys to move cursor, <enter> to select program

Data preparation utilities

Figure 2-1 GeoEAS System Menu

### 2.2.2 Using the Programs From DOS

To run the programs from DOS, type the program name at the DOS prompt. For example, to start program Stat1 type: STAT1 <enter>

# SECTION 3

# SYSTEM OPERATION

## 3.1 DATA

### 3.1.1 Geo-EAS Data Files

All programs in the system use a common format for data files. (Note: the term "Data File" is used to denote a specific type of file used by GeoEAS programs, as opposed to Pair Comparison files, Parameter files, or Metacode files). Data files are simple ASCII text files which may be created with any text editor. It is important to be familiar with this format, and to make sure your data files are compatible, or the programs will not be able to read them. An example data file has been included with the distribution diskettes. It is called "Example.dat". Below is an explanation of the data file format.

Line 1 - Title

This line is a descriptive title which may contain up to 80 characters. Most programs display the title on the screen when the file is read into memory. Some programs will use the title as the default title for graphics screens.

Line 2 - Number of Variables (NVAR)

This line tells the programs how many variables are in the data file. The data are stored in rows and columns, where each column contains a different variable, or measured quantity, and each row represents a different sample location, time, etc. The data file may hold up to 48 variables (columns). Different programs have different limits on the number of samples (rows) which can be read. Typically, up to 1000 samples may be read. If a program encounters more than its limit of samples, the remaining samples will not be read into memory, and will not be used for computation.

Line 3 to NVAR+2 - Variable Names and Measurement Units

The lines following the number of variables must contain the names and the measurement units for each variable (1 line per variable). The variable name must be the first 10 characters in the line, and the units (optional) must be characters 11-20. When a data file is accessed by a program, the variable names are stored into toggle fields. This allows one to select variables by name, and provides some internal documentation of data file contents. Variable names will be used as default labels for graph axes, in graphic displays.

### Line NVAR+3 To End of File - the Data Matrix

This is where the data are stored. Columns represent variables, and rows represent samples. The data may be in "free format", which means that in a given line in the file, variable values must be separated by at least one space, or a single comma. For readability, columns of numbers should line up, although this is not required. Variable values must be numeric with no embedded blanks. In many cases, several variables may be present in a data set, but for some reason a value could not be obtained for a particular variable in a particular sample. A special value may be given to the variable in this sample which will indicate to a program that the value is missing, so that it will not be used in calculations. The special value reserved for this is 1.E31. This is "scientific notation" for a 1 followed by 31 zeros. If your data set has missing values, be sure to type a 1.E31 where the real value would have appeared. Below is a portion of the file Example.dat. It contains 5 variables and 60 samples.

```
Example.dat - Geostatistical Environmental Assessment Software
    5
Easting   feet
Northing  feet
Arsenic   ppm
Cadmium   ppm
Lead      ppm
   288.0  311.0  .850  11.5  18.25
   285.6  288.0  .630  8.50  30.25
   273.6  269.0  1.02  7.00  20.00
   280.8  249.0  1.02  10.7  19.25
   273.6  231.0  1.01  11.2  151.5
   276.0  206.0  1.47  11.6  37.50
   285.6  182.0  .720  7.20  80.00
   288.0  164.0  .300  5.70  46.00
   292.8  137.0  .360  5.20  10.00
    ...    ...    ...   ...    ...
```

### 3.1.2 File Naming Conventions

Only valid DOS file names will be accepted by the programs. For more information on DOS file names, refer to the DOS reference manual. All file names used by the Geo-EAS programs are associated with a File Prefix. The File Prefix provides a means of specifying a drive, or subdirectory where data files should be accessed. This option is discussed in detail in the section below (Common Menu Options). Although the programs place no restriction on file extensions, it is good practice to use consistent naming conventions for file extensions. Below are the suggested extensions which are used as defaults in Geo-EAS programs.

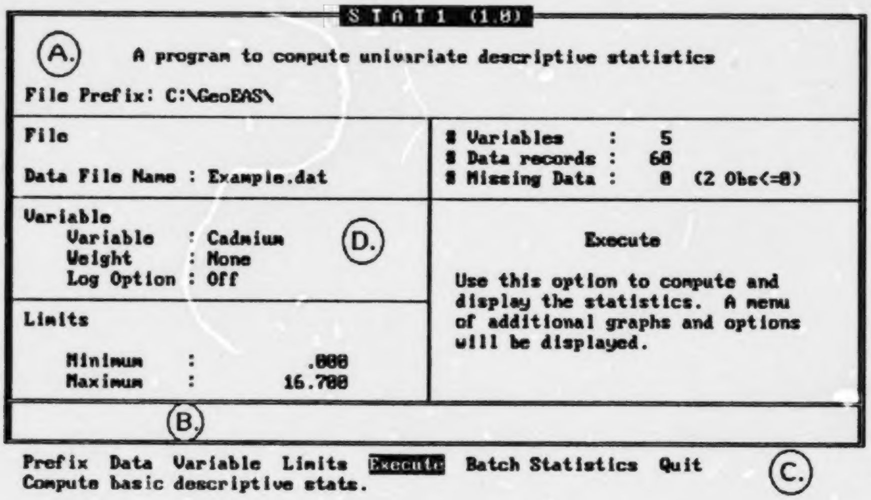
Geo-EAS File Extensions:

.TXT - an ASCII text file
.DAT - a Geo-EAS data file
.PCF - a pair comparison file, created by PREVAR, read by VARIO
.GRD - a gridded Geo-EAS data file (could be produced by KRIGE)
.CPF - CONREC parameter file
.KPF - KRIGE parameter file
.XPF - XYGRAPH parameter file
.POL - Polygon boundary file, used by KRIGE
.MET - metacode (graph) file, created by CONREC, POSTPLOT, and XYGRAPH, and used by HPPLOT, and VIEW
.PLT - plotter instruction file, produced by HPPLOT

## 3.2 INTERACTIVE SCREENS

### 3.2.1 Screen Format

All Geo-EAS programs have similar interactive features. Each program uses interactive screens for selection of program options and display of results. The screens are composed of several common components. Figure 3-1 displays an example interactive screen from program Stat1. Below is a description of the common components.



```
A program to compute univariate descriptive statistics

File Prefix: C:\GeoEAS\

File                                   # Variables    :    5
                                       # Data records :   60
Data File Name : Example.dat           # Missing Data :    0  (2 Obs<=0)

Variable
    Variable   : Cadmium                           Execute
    Weight     : None
    Log Option : Off                   Use this option to compute and
                                       display the statistics.  A menu
Limits                                 of additional graphs and options
                                       will be displayed.
    Minimum    :           .000
    Maximum    :         16.700

Compute basic descriptive stats.
```

Figure 3-1 Example Interactive Screen

### A. The Screen Frame

This is the large double-line rectangle which encloses each screen. Program inputs and results are displayed in this area. Typically, the screen frame is subdivided into smaller single-line rectangles. Each of these smaller rectangles contains a functionally-related group of one or more input parameters, or program results.

### B. The Message Line

This is the double line rectangle at the bottom of the screen frame. This area is used to display program error messages, yes/no prompts, prompts for additional information, or instructions for using a program option.

### C. The Menu Line

This is the line of text located just below the screen frame. It contains a set of menu option names and a highlighted box (cursor bar). The cursor bar can be moved along the menu line by using the <left>, and <right> cursor control keys. As the cursor bar is moved over a menu option name, a short description of the menu option is displayed on the line just below the menu line. This line is called the menu description line. In addition, on the main screen for each program, more detailed descriptions of the menu options are displayed. You may explore the possible choices in a program by moving the cursor bar and reading the descriptive messages which accompany each menu option. To select a menu option, move the cursor bar over the desired menu option name, and press <enter>. An alternative (and faster) way to select menu options is to press the key which corresponds to the first letter in the menu option name. The result is the same as using the cursor control keys, and pressing <enter>. In program Stat1 for example, you would choose to enter the data file name by pressing <d> (for the Data option) from the main menu.

### D. Parameter Groups

Typically, a functionally-related group of program input parameters (fields) are enclosed together on the screen by a single-line rectangle. These groups of parameters are accessed through the menu. When a menu option is selected (as described above), a cursor bar appears at the screen field, and a message describing what action to take appears on the message line. When such a group contains several fields, the cursor control keys, or <enter> are used to move to subsequent fields. Exiting from the last field in the group will return the cursor bar to the menu line. In some programs, parameter groups are arranged in a tabular fashion (rows and columns). To return to the menu line from such a group, move the cursor bar to the left or bottom of the group with the <left> or <down> keys.

### 3.2.2 Types of Screen Input Fields

Several types of input fields are provided to allow flexibility in program parameter specification. Below is a list of these types, and an example of each field type in the Stat1 screen:

**Alphanumeric Fields** - These fields may contain character strings of alphabetic or numeric characters. Any alphanumeric characters may be entered. The "Prefix", and "Data" menu options in Stat1 require alphanumeric values to be entered. To specify a data file name, select the Data option on the menu, and type the name of the input data file.

**Numeric Fields** - Only numeric data may be entered into numeric fields. Some numeric fields will only accept integer (non-decimal) numbers. The programs will respond to any erroneous keystrokes (such as alphabetic keys) with a low-pitched error tone. An example of numeric fields in program Stat1 are the two fields accessed through the Limits option Only numeric values may be entered into these fields. Values must be entered in the conventional manner (legal characters are <0> through <9>, and <.>, exponential notation for numeric values is not allowed.)

**Toggle Fields** - A toggle field is a special type of field which contains a list of 2 or more preset choices. Only one of these choices is displayed in the field. The <space> key is used to change the displayed choice, and the <enter> key is used to make the selection. Two examples of toggle fields in program Stat1 are the "Variable" field and the "Log" field. Once a file name has been specified, the "Variable" toggle field will contain the names of all variables in the file. When the Variable option on the menu line is selected, this field will be highlighted, and each time the <space> key is pressed, a new variable name will appear in the field. When the desired variable name appears, press the <enter> key to select it. The "Log" field is an example of a toggle field with only two choices ("On", or "Off"). If "On" is chosen, then statistics will be calculated for the log of the selected variable.

**Yes/No prompts, prompts for additional information** - These prompts are for information which will not be displayed permanently on the screen. They will appear temporarily on the message line. A Yes/No prompt will typically have the form: "Question...<Y/N>?". To respond Yes, press the <Y> key, to respond in the negative, press any other key. A typical Yes/No prompt is the "Do you really want to Quit <Y/N> ?" prompt which is displayed after the "Quit" (terminate program) option is selected. Some menu choices will result in prompts for additional information. These prompts for additional information will appear on the message line and may be of the alphanumeric, numeric, or toggle type.

### 3.2.3 The Menu Tree

The programs in the Geo-EAS system require input typically from data files and through interaction on the screen. These program inputs are arranged in a hierarchy of functionally-related groups. Each group, or individual program parameter value is accessed through a menu of choices. Some choices will lead to other menus, while some will lead to prompts for groups of one or more inputs. Such an arrangement can be represented in a "menu tree" as illustrated below for program Stat1.

**Example menu tree**

```
Stat1    ---- Prefix
             | Data
             | Variable
             | Limits
             | Execute --------- Histogram ------ Type
             |                  |                | Class Limits
             |                  |                | Axes
             |                  |                | Title
             |                  |                | Results
             |                  |                | View Graph
             |                  |                \ Quit
             |                  |
             |                  | Probability Plot
             |                  | Examine
             |                  \ Quit
             |
             | Batch Statistics
             \ Quit
```

In the Stat1 menu tree, as in other programs, some menu choices will lead to program inputs, and some will produce numeric or graphical results. This hierarchy of options and results is a natural and convenient way of providing choices for program use. The "menu tree" representation of program options provides a "road map" for each program which summarizes the functional capabilities of a program. You may explore the hierarchy of options by traversing the menu tree and reading the descriptive messages which appear.

### 3.2.4 Common Menu Options

Many of the programs in the Geo-EAS system share common menu options. These will be discussed in this section to avoid redundancy. Any minor differences which apply to a particular program will be discussed later in detail. The following is a list of options common to many programs:

### Prefix

This option is common to all Geo-EAS programs. It is used to specify a string of up to 50 alphanumeric characters which are used as a prefix for all files accessed by a program. Typically, it is used to include a disk drive and/or a directory specification. Before a file is accessed by a program, a file name is constructed which consists of the File Prefix followed by the given file name. File name errors are not caught by the programs until they have attempted to access a file. Consequently, "file not found" error messages are not issued until an attempt to access the file has been made. This may be due to a mistake in the file prefix or file name specified.

### Data

This option is common to most Geo-EAS programs. It is used to indicate the Geo-EAS input data file to be used by the program. File names consist of 14 alpha-numeric characters. Any valid DOS file name may be used. The File Prefix (discussed above) is used to construct the entire file name when the file is accessed by the program. If any errors occur while the programs are accessing or reading a data file a message indicating the problem will be issued. If a "file not found" message is displayed, the problem may be with the file prefix (see above). If no errors occur, the variable names are read from the data file and stored into toggle fields for use by the Variables option.

### Variable(s)

This option is common to all programs which use Geo-EAS data files. It allows you to specify the variable (or variables) which the program will use. Some programs only use one variable (e.g. Stat1) and others require three (e.g. CONREC). Typically, this option will provide access to one or more toggle fields which contain the variable names. Some programs include additional fields for selection of other parameters related to the choice of variables. These will be explained in the particular section which describes the program.

### Execute

This option is common to all Geo-EAS programs. It is used to initiate processing of data by the program. Although the processing and interaction subsequent to the selection of this option is different for each program, it shares the common function of initiation of processing. The individual differences in processing will be described in more detail in the subsections which describe the programs.

### Read Parameters, Save Parameters

These options are common to all Geo-EAS programs which make use of "Parameter Files". Parameter Files are files which contain values for all parameter choices available in a particular program. If a program provides this feature, you may save the values of parameters for later use, by using the Save Parameters option. Selection of this option will result in a prompt for the output parameter file name. The File Prefix is used to create or access the file. The Read Parameters option is used to load the parameter values into the program. When this option is selected, an input parameter file name must be entered. Typically, a program will attempt to load all data and set all parameter values based upon the information in the input parameter file. It is assumed that the data file associated with the parameter file is in the same location (subdirectory, etc.) as it was when the parameter file was saved. If any errors occur while accessing or reading the parameter file or the associated data file, an error message will be issued and the program will re-initialize all parameter values to their defaults. Conventions should be used when naming parameter files so that they can be associated with the appropriate data files and programs. A suggested convention for file extensions is given in a previous section (File Naming Conventions). It is also suggested that the first part of the file name have some similarity to the associated data file name.

### Quit

This option is common to all Geo-EAS programs. It is used to exit from a menu, or program. Using the analogy of the Menu Tree, the quit option allows you to "move up" one level in the tree. When the quit option is used from the main menu of a particular program, a Yes/No prompt is issued: "Do you really want to quit <Y/N> ?". The <q> key is typically used to select this option. The Yes/No prompt is a means of ensuring that a series of <q> keystrokes will not cause inadvertent termination of the program.

## 3.3 Geo-EAS GRAPHICS

### 3.3.1 On-Screen Graphics

Many Geo-EAS programs have graphics capability. Each such program uses graphics in one of two ways. Programs Stat1, Vario, Xvalid, and Krige plot graphics directly on the screen. This approach is used to provide a quick look at data, or program results. Such graphics displays may be printed on a dot-matrix printer, but may not otherwise be saved or modified. When a graphics screen is displayed, the program will wait for a key to be pressed. Pressing <q> will cause an interactive screen and menu to be displayed. Pressing <p> will produce a hard copy of the screen on a graphics printer. It is important to make sure that a graphics printer is connected to your computer if you choose this option, or the program will "lock-up". Also make sure that the printer is turned on and "online". If the program "locks up", you will probably have to re-start the computer. (See the section on Error and Recovery Procedures for more information).

### 3.3.2 Metacode-Based Graphics

Postplot, Xygraph, and Conrec also plot graphics on the screen, but only after writing a "metacode" file. A metacode file is a file of device-independent plotting instructions. These files can be used later to redisplay the graph on the screen, or to plot it on a pen plotter. Internally in these programs, the metacode is written by a set of public-domain FORTRAN subroutines produced at the National Center for Atmospheric Research (NCAR, in Boulder, CO.) by their Scientific Computing Division. These files are used by special translator programs called "metacode translators", which convert the metacode into device-specific graphics commands. Currently, only two metacode translators are provided. Program View translates metacode into video graphics for EGA, CGA, and Hercules graphics hardware, and program Hpplot will convert metacode into HPGL (Hewlett Packard Graphics Language) plotting instructions. Each metacode-producing program uses a version of view to display the graphs during an interactive session. Since producing and translating metacode takes longer than sending graphics commands directly to the display, these programs take longer to draw graphs than the non-metacode producing programs. The advantage to using metacode is the capability of obtaining higher-quality graphic output on a pen plotter or other graphics device.

## 3.4 ERROR AND RECOVERY PROCEDURES

### Normal Error Processing

A great deal of effort has been put into error checking into the programs. This includes bounds checking on numeric parameters, file names, file Input/Output, and file existence. When errors of these types are encountered in programs, error messages are displayed on the message line at the bottom of the screen. These messages are displayed in a black-on-white format (reverse). A typical error message is "Error encountered while reading data file...(press any key)". These messages will remain on the screen until a key is pressed. To return to the interactive screen after such a message is displayed, press any key.

### Bugs

As everyone knows, people make mistakes. Because computer programs are designed by people they usually contain mistakes, or errors in program(mer) logic called "bugs". The Geo-EAS programs have been extensively tested, and many bugs have been uncovered and corrected. No known bugs have been allowed to remain, however it is entirely possible that there are still a few bugs lurking in the depths of some of the programs. It is still possible that there are situations which will cause some programs to "crash", or "fail" (terminate prematurely), or to "lock-up" (pause indefinitely with no response). If a program "locks-up", the computer system must be re-started. It may be due to a bug, or due to a printer or disk-drive problem (see below) If a program terminates prematurely it is probably due to a bug.

### Bug Reporting (how you can help):

If you encounter a problem and you think it may be a significant bug, a bug report would be greatly appreciated. When you suspect a bug and want to report it, there are several steps that you should take: First, you should try to reproduce it (make it happen more than once). If a bug is not reproducible, it will be very difficult to determine the cause. Secondly, you should make note of the exact sequence of inputs which caused the problem, including your hardware configuration (if known). This information should be included on paper or diskette along with a description of the problem, so that the bug may be corrected. A detailed description and all program inputs will allow the programmers to reproduce the error and solve it more quickly. Every effort will be made to correct significant program errors as soon as possible. Check the READ.ME file in the software distribution, where known bugs may be reported.

**Known "bugs":**

Xygrapn or Postplot may fail when certain incompatible combinations of axis tickmark parameters are chosen. This is dependent upon the data configuration and choice of parameters, and is due to internal limitations in the NCAR graphics utilities which these program use.

Postplot may produce undesirable scaling in plots with certain sample data configurations. An attempt is made by the software to produce "true-proportion" post plots. The underlying NCAR utilities which produce the metacode files sometimes override the scaling specified by Postplot. This is an unexplainable phenomenon which has not and unfortunately will not be corrected.

Trans may crash when an operation is chosen which would produce a very large or very small number. An example would be the operation 1.0 / X, or 10 ** X, when X is very small or very large (1.E-1000, 1.E1000). This type of program error cannot be trapped or handled by Trans. In such cases the result cannot be produced due to hardware limitations in the precision of the numeric coprocessor (or floating-point emulation software). Since there is no remedy for this situation. The only solution is to avoid such operations.

**Avoiding User-Induced Errors:**

There are several error conditions which the program was specifically not designed to check for. These involve checking to see if disk or printer peripherals are connected and ready for data transfer. You are responsible for ensuring that printers are attached and online, or that disk drives have the correct density media and are ready for read/write operations, when Read Save, or Write options are selected. The following actions are guaranteed to create a "lock-up" situation.

- Trying to print a text or graphics screen when the printer is not connected, or on-line. If a printer is connected, make sure it is turned "on", and is ready to accept output from the computer (on-line). If no printer is connected to your system you may have to "re-boot" the computer (in this case, you should avoid trying to print a text or graphics screen in the first place).

- Accessing a file on a floppy diskette drive when the disk drive door is open,or no diskette is present. In some cases, DOS may respond with a message: Device not Ready (Abort, Retry, Ignore). Insert a diskette and press <r> (for Retry). If this does not work, you must re-start the computer.

# SECTION 4

## USING Geo-EAS IN A GEOSTATISTICAL STUDY: AN EXAMPLE

### 4.1 OVERVIEW

This section will demonstrate how to use Geo-EAS software to conduct a geostatistical study. Starting with an example data set from a hypothetical pollution plume, you will work through a complete study, using many of the Geo-EAS programs in the process. Of necessity, this exercise will be somewhat abbreviated. We will conduct a relatively straightforward study, illustrating the options which are likely to be most commonly used. The data set (example.dat) has been included with the software, so that you may repeat the exercise as a tutorial, or to test the software.

The scenario for the example is that data has been acquired from analyses of 60 soil samples at a site contaminated with arsenic, cadmium, and lead. The basic objectives are to examine the data set for possible errors or outliers, and to construct contour maps of each of the variables to define the areas of highest concentration. In this example you will work primarily with the variable Cadmium; you are encouraged to try out these procedures with the arsenic or lead data.

#### The Example Data Set

The Example.dat data set is an ASCII file in the Geo-EAS format. It contains data from 60 sample locations. The file structure is described in Section 3 above. The first few lines are as follows:

```
Example.dat - Geostatistical Environmental Assessment Software
     5
Easting   feet
Northing  feet
Arsenic   ppm
Cadmium   ppm
Lead      ppm
   288.0  311.0  .850  11.5  18.25
   285.6  288.0  .630  8.50  30.25
   273.6  269.0  1.02  7.00  20.00
   280.8  249.0  1.02  10.7  19.25
```

## 4.2 EXPLORATORY DATA ANALYSIS

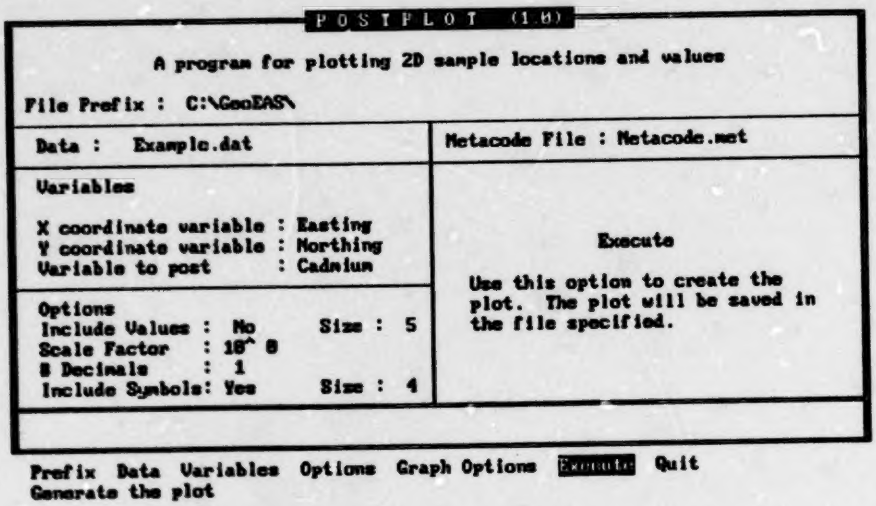
The first order of business in any data analysis is to become familiar with the data set. You will use a combination of statistics and graphical displays to look at the range and shape of the frequency distribution, to look for data outliers which may be erroneous or unrepresentative, to look at the "spatial coverage" of the data, and to look for spatial patterns in the data.

Begin by taking a look at a map of the data produced by the program Postplot. Assuming that you have already copied the software and data into a directory called Geoeas on your hard disk, and have used the command "CD \Geoeas" to access the directory, you can run Postplot either by:

(1) using the DOS command C:\GEOEAS> **Geoeas <enter>** to enter the system menu, moving the cursor to the Postplot option with the arrow keys, and pressing <Enter>, or by

(2) running the program directly from DOS by typing the command C:\GEOEAS> **Postplot <enter>**.

When the program begins execution, it first displays a screen with introductory information. When you press a key to proceed, you will see the program main screen and menu, as displayed in Figure 4-1.



```
A program for plotting 2D sample locations and values

File Prefix :  C:\GeoEAS\

Data :   Example.dat                  Metacode File : Metacode.met

Variables

X coordinate variable : Easting                 Execute
Y coordinate variable : Northing
Variable to post      : Cadmium       Use this option to create the
                                      plot.  The plot will be saved in
Options                               the file specified.
Include Values :  No      Size :  5
Scale Factor   : 10^ 0
# Decimals     :  1
Include Symbols: Yes      Size :  4

Generate the plot
```

Figure 4-1     PostPlot Main Screen

The bottom line on the screen provides the list of available options. The first five move you to an area on the screen (or to a new screen) where you can input or select program parameters. The Execute option starts the actual processing portion of the program, and Quit moves you to the preceding menu (or out of the program). All menus in the system operate in a similar way: options are selected by moving the highlighted bar to the desired option name with the arrow keys and pressing <enter>, or by typing the first character of the option name.

> *** NOTE *** Whenever feasible, the programs will use default options and values. These may be preset, computed from the available data, or passed from a previously run program. Be careful! The computer doesn't understand your problem or your data. Defaults make it easy to get a result quickly, not necessarily to get an appropriate result. In this example we will usually use the defaults to get quick results. Try other options to get familiar with the full range of system capabilities.

In Postplot, the minimum that you MUST do to obtain a plot is:

1. Use the Data option to enter the name of a Geo-EAS data file (or accept the default name, if one is provided).

2. Use the Variable option to select the X and Y variables and the desired variable for posting (or accept defaults).

3. Use the Execute option to enter a name for the metacode file (or accept the default), create the metacode file, and display the map.

In this case you can skip the Prefix option because the data file is in the Geoeas directory, and enter the file name Example.dat with the Data option. The program reads the data file, and automatically executes the Variable option. The program assumes that the X and Y variables are the first and second in the file, respectively. This is correct, so you should accept both by pressing <enter> twice. The program also assumes that the third variable is the one we want to post. This is incorrect - we want Cadmium, not Arsenic - so use the <space> key to toggle through the list of variables until Cadmium is found, and then press <enter>. Now use the Execute option; it will move you to the metacode file name field. Accept the default metacode file name (Metacode.met is effectively a permanent scratch file) and wait for the plot to appear on the screen. After examining the plot, hit <q> to return to the main menu, and use the Quit option to return to the system menu (or DOS).

To simplify our explanations in the future, an abbreviated notation for the above sequence of events will be used. A general formula exists for each option: initiate the option; then take one or more actions, each of which may result in a screen field taking a particular value. The above sequence thus becomes:

| OPTION | ACTION | FIELD | VALUE |
|---|---|---|---|
| DATA | Enter | Data File | Example.dat |
| VARIABLE | Accept | x | Easting |
|  | Accept | y | Northing |
|  | Select | variable | Cadmium |
| EXECUTE | Accept | metacode file | Mecode.met |
| <Q> |  |  |  |
| QUIT | Answer |  | Y |

The resulting Post plot is shown in Figure 4-2.

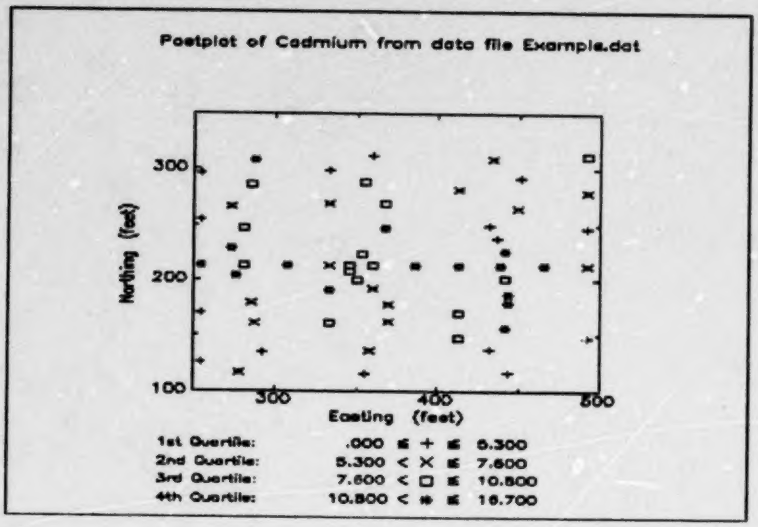


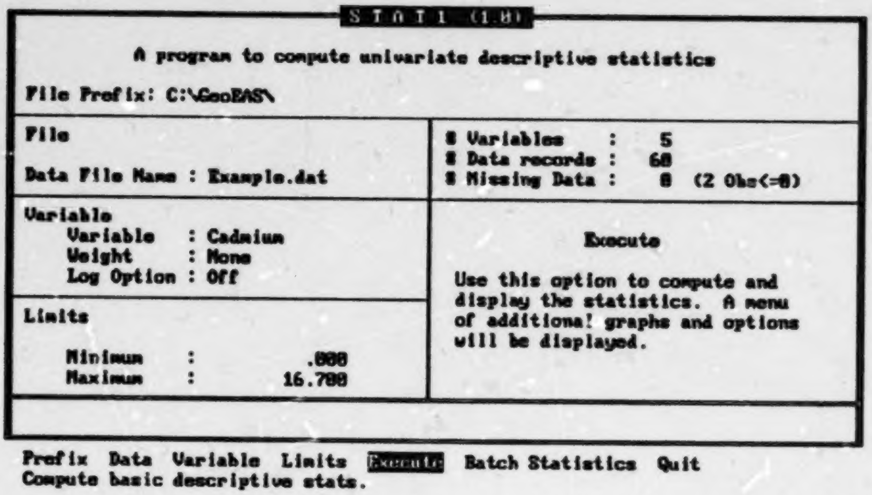
Figure 4-2 Post Plot of Cadmium

From this plot you can see that the samples fall in a rectangular area about 250 by 220 feet. The sample locations are irregularly spaced, and although there are some gaps and clusters, they provide relatively uniform coverage over the entire rectangle. The symbols/colors represent the quartiles for the cadmium values, with */red as the upper quartile, and +/blue as the lower. A general trend can be seen in the cadmium values: The highest values occur in a rough E-W band through the center of the plot, while the lowest fall in parallel bands at the north and south margins. The * in the northwest corner of the area seems to be an exception to the trend; it seems too high compared to its surroundings. Such "spatial outliers" should be checked to confirm that their coordinates and data values are valid. For this example, you will assume that this sample is valid.

While the plot is on your screen, you will note that there is no menu line at the bottom. What do you do now? Every graphics screen actually has two "invisible" options available - <p> (Print) and <q> (Quit), which produces a screen dump on your printer, and returns you to the main menu, respectively.

*** NOTE *** Don't try a screen dump if your printer is not connected and turned on - the program will "hang up" and you will have to re-boot with <ctrl>-<alt>-<del>!

Now you should use program Stat1 to generate some statistics on the data. When Stat1 is initiated, the Main screen will be displayed as in Figure 4-3.



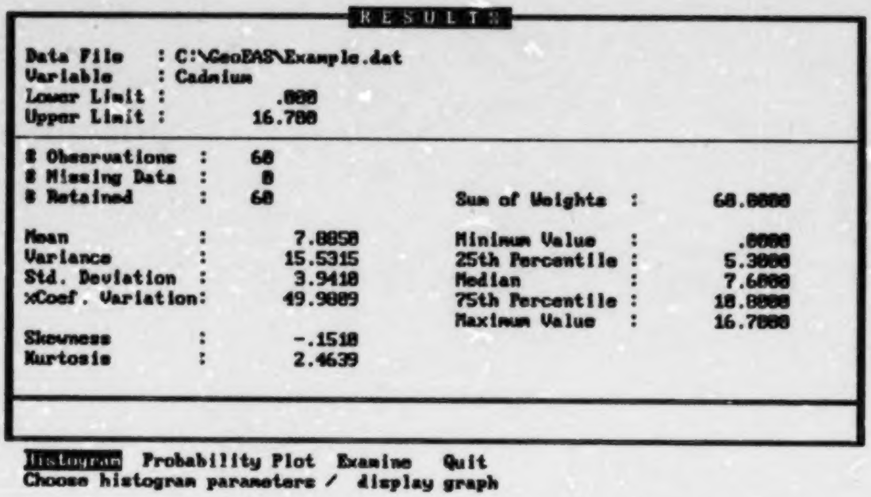
```
                         S T A T 1  (1.0)
        A program to compute univariate descriptive statistics

File Prefix: C:\GeoEAS\

File                                 # Variables    :    5
                                     # Data records :   60
Data File Name : Example.dat         # Missing Data :    0  (2 Obs<=0)

Variable
    Variable   : Cadmium                        Execute
    Weight     : None
    Log Option : Off                 Use this option to compute and
                                     display the statistics.  A menu
Limits                               of additional graphs and options
                                     will be displayed.
    Minimum    :           .000
    Maximum    :         16.700

Prefix  Data  Variable  Limits  Execute  Batch Statistics  Quit
Compute basic descriptive stats.
```

Figure 4-3 Stat1 Main Screen

The option sequence below is the minimum required to compute univariate statistics and display a histogram and a probability plot for the variable Cadmium. Note that a default file name (Example.dat) has been carried forward from the previous program. When you finish examining the histogram, you do not go directly back to the main menu; an intermediate menu lets you select alternate options for replotting the histogram.

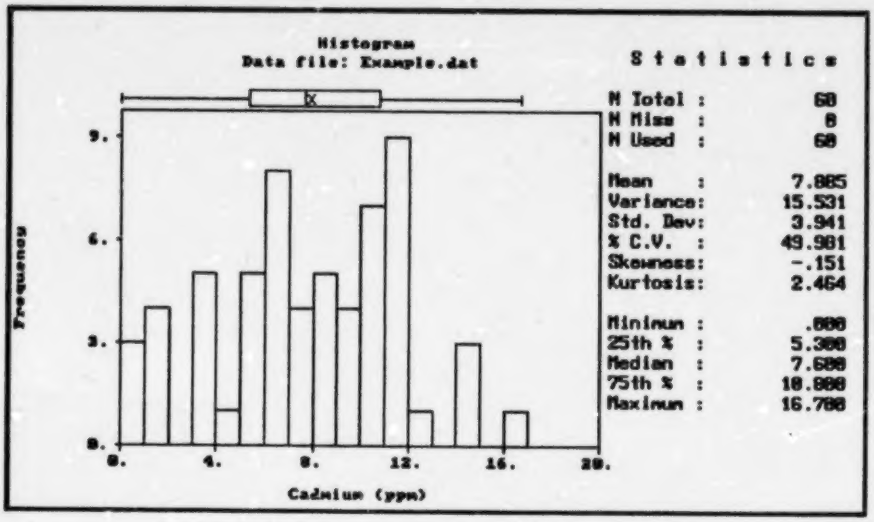
| COMMAND | ACTION | FIELD | VALUE |
|---|---|---|---|
| DATA | Accept | Data File | Example.dat |
| VARIABLE | Select | variable | Cadmium |
| | Accept | weight | None |
| | Accept | log option | Off |
| EXECUTE | | | |
| HISTOGRAM | | | |
| <Q> | | | |
| QUIT | | | |
| PROB.PLOT | | | |
| <Q> | | | |

The univariate statistics, histogram, and Probability plot are generated. Figure 4-4 displays the univariate statistics for cadmium. Figures 4-5 and 4-6 display the histogram and probability plot for cadmium.



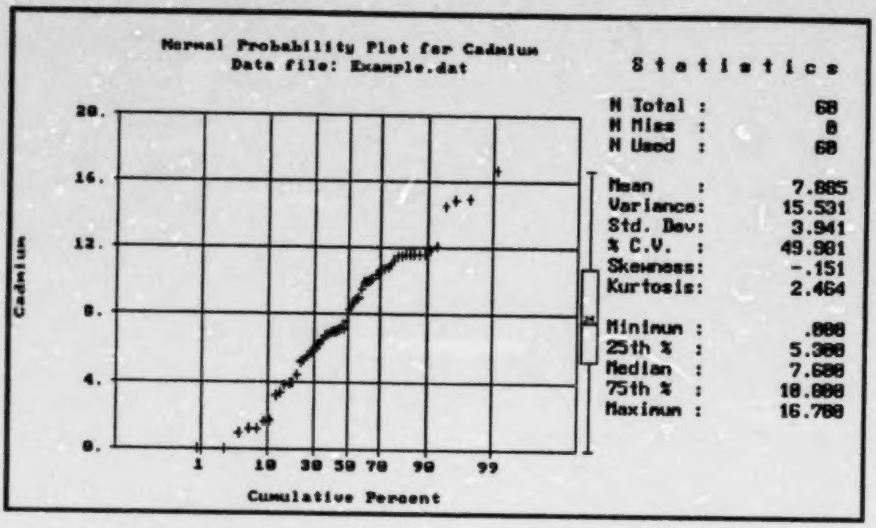
```
                                    RESULTS

Data File    : C:\GeoEAS\Example.dat
Variable     : Cadmium
Lower Limit :            .000
Upper Limit :          16.700

# Observations  :    60
# Missing Data  :     0
# Retained      :    60                 Sum of Weights   :       60.0000

Mean            :          7.8850       Minimum Value    :         .0000
Variance        :         15.5315       25th Percentile  :        5.3000
Std. Deviation  :          3.9410       Median           :        7.6000
%Coef. Variation:         49.9809       75th Percentile  :       10.0000
                                        Maximum Value    :       16.7000
Skewness        :          -.1510
Kurtosis        :          2.4639

Histogram  Probability Plot  Examine   Quit
Choose histogram parameters /  display graph
```

Figure 4-4     Stat1 Results Screen



```
Statistics

N Total :      60
N Miss  :       0
N Used  :      60

Mean     :  7.885
Variance: 15.531
Std. Dev:   3.941
% C.V.   : 49.981
Skewness:   -.151
Kurtosis:   2.464

Mininun :    .000
25th %   :  5.300
Median   :  7.600
75th %   : 10.000
Maxinun : 16.700
```

Figure 4-5     Histogram of Cadmium



```
S t a t i s t i c s

N Total :        60
N Miss  :         0
N Used  :        60

Mean     :    7.885
Variance:    15.531
Std. Dev:     3.941
% C.V.  :    49.981
Skewness:     -.151
Kurtosis:     2.464

Minimum :      .000
25th %  :     5.300
Median  :     7.600
75th %  :    10.000
Maximum :    16.700
```

Figure 4-6     Cadmium Probability Plot

From the histogram and the statistics, it can be seen that this data set is nearly symmetrical about the mean value (the mean is close to the median, and approximately halfway between the minimum and maximum values). There are no suspect outliers. The probability plot shows that the data set approximates a normal distribution (a probability plot is a cumulative frequency plot scaled so that a normal distribution plots as a straight line). Whether a distribution is normal, log-normal, or something else has no particular geostatistical significance, except that it is often more difficult to interpret variograms for highly skewed distributions such as the log-normal, and in such cases it may be useful to also compute variograms on log-transformed data.

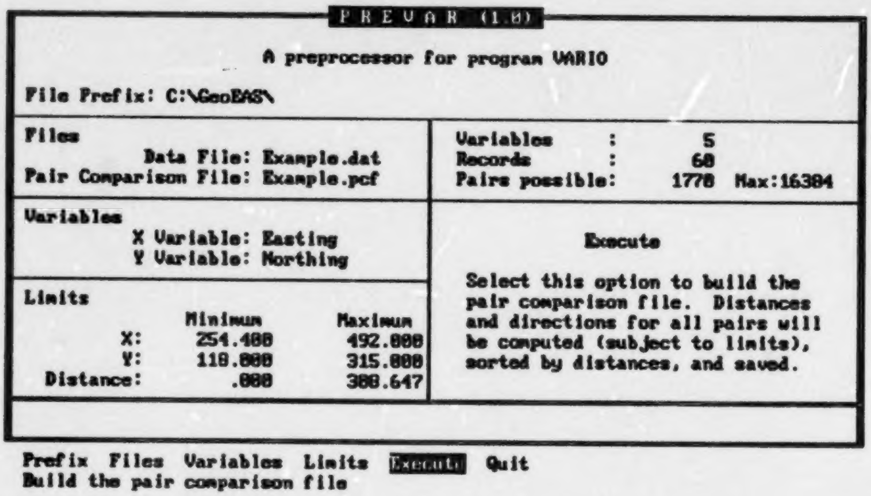
## 4.3 VARIOGRAM ANALYSIS

The computation, interpretation, and modeling of variograms is the "heart" of a geostatistical study. The variogram model is your interpretation of the spatial correlation structure of the sample data set. It controls the way that kriging weights are assigned to samples during interpolation, and consequently controls the quality of the results.

All interpolation and contouring methods make the assumption that some type of spatial correlation is present, that is, they assume that a measurement at any point represents nearby locations better than locations farther away. Variogram analysis attempts to quantify this relationship: How well can a measurement be expected to represent another location a specific distance (and direction) away? Experimental variograms plot the average difference (actually, one-half the squared difference, or variance) of pairs of measurements against the distances separating the pairs. If you had measurements at all possible sample locations, you could compute the "true variogram" for a site, i.e., the variance of all pairs of measurements which satisfy each combination of distance and direction. In practice, with limited data, you compute the variances for groups of pairs of measurements in class intervals of similar distance and direction. You then plot a graph of the variances versus distance for a particular direction, and fit a model curve to the graph; the model is assumed to be an approximation of the "true variogram".

Continuing with the example, we will use Prevar to create an intermediate file of data pairs, and Vario to compute, plot, and model variograms. No automatic model fitting is provided; we will use Vario to superimpose plots of various model curves on the experimental variogram until we find one that looks right.

Prevar is a simple program with only a few options to allow you to reduce the number of sample pairs in the output file to the maximum allowed by Vario by setting minimum and maximum limits on X and Y, and by setting a maximum distance for pairs. This is necessary when the number of samples in the data set exceeds 181. Upon initiating Prevar, the main screen will be displayed, as in Figure 4-7.



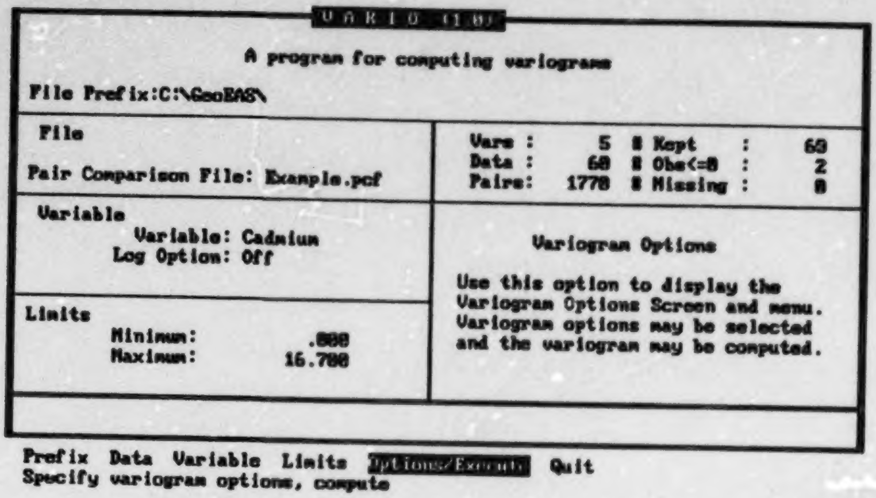
```
PREVAR (1.0)

A preprocessor for program VARIO

File Prefix: C:\GeoEAS\

Files                                    Variables      :       5
         Data File: Example.dat          Records        :      60
Pair Comparison File: Example.pcf        Pairs possible:     1770  Max:16384

Variables
         X Variable: Easting                       Execute
         Y Variable: Northing
                                         Select this option to build the
Limits                                   pair comparison file.  Distances
              Minimum        Maximum     and directions for all pairs will
       X:     254.400        492.000     be computed (subject to limits),
       Y:     110.000        315.000     sorted by distances, and saved.
 Distance:       .000        300.647

Build the pair comparison file
```

Figure 4-7 Prevar Main Screen

The option sequence below creates the pair comparison file Example.pcf.

| OPTION | ACTION | FIELD | VALUE |
|---|---|---|---|
| FILES | Accept | Data File | Example.dat |
|  | Accept | Pairs File | Example.pcf |
| EXECUTE |  |  |  |
| QUIT | Answer |  | Y |

Next, initiate Vario, and the Vario Main screen is displayed, as in Figure 4-8.



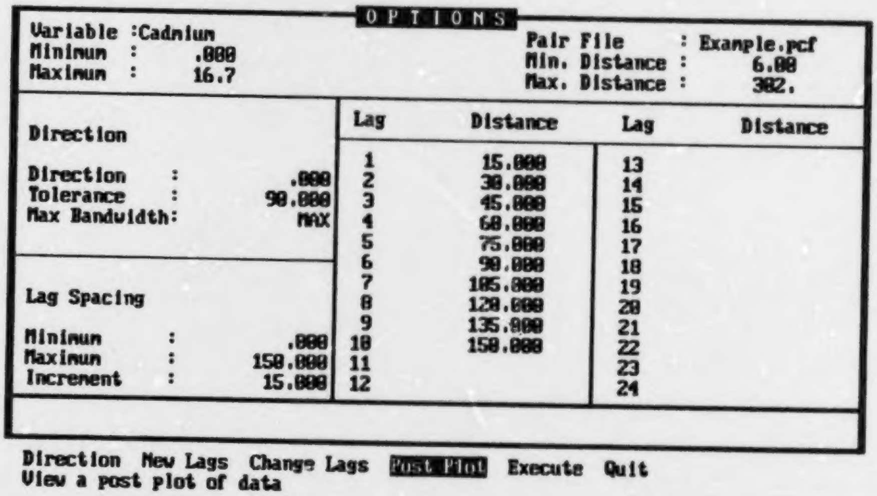
```
VARIO (1.0)
                         A program for computing variograms
File Prefix:C:\GeoEAS\
File                                    Vars :      5  # Kept      :      60
Pair Comparison File: Example.pcf       Data :     60  # Obs<=0    :       2
                                        Pairs:   1770  # Missing   :       0
Variable
      Variable: Cadmium                        Variogram Options
    Log Option: Off
                                        Use this option to display the
Limits                                  Variogram Options Screen and menu.
      Minimum:            .000          Variogram options may be selected
      Maximum:          16.700          and the variogram may be computed.

Prefix  Data  Variable  Limits  Options/Execute  Quit
Specify variogram options, compute
```

Figure 4-8     Vario Main Screen

The following option sequence reads the pair comparison file into memory, and moves to the next menu:

| OPTION | ACTION | FIELD | VALUE |
|---|---|---|---|
| DATA | Accept | Pairs File | Example.pcf |
| VARIABLE | Toggle | Variable | Cadmium |
| | Accept | Log Option | Off |
| OPTIONS/EXECUTE | | | |

The Options/Execute menu allows us to specify how we want the experimental variogram to be computed. This screen and menu is displayed in Figure 4-9.



```
OPTIONS
Variable :Cadmium                               Pair File      : Example.pcf
Minimum  :     .000                             Min. Distance  :     6.00
Maximum  :     16.7                             Max. Distance  :     302.

Direction                     Lag    Distance      Lag      Distance

Direction    :        .000     1      15.000        13
Tolerance    :      90.000     2      30.000        14
Max Bandwidth:         MAX     3      45.000        15
                               4      60.000        16
                               5      75.000        17
                               6      90.000        18
Lag Spacing                    7     105.000        19
                               8     120.000        20
                               9     135.000        21
Minimum      :        .000    10     150.000        22
Maximum      :     150.000    11                    23
Increment    :      15.000    12                    24

Direction  New Lags  Change Lags  Post Plot  Execute  Quit
View a post plot of data
```

Figure 4-9     Vario Options Screen

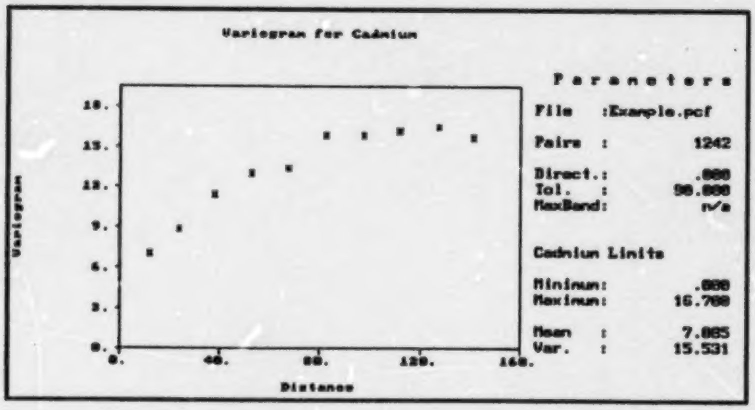
First, specify the distance class intervals (lags) and directional tolerances for computing the variogram. Finding the "right" combination is a trial and error exercise, but a systematic approach can be helpful:

To start, you will use the default direction, which is an "omnidirectional" variogram. The angular tolerance of 90 degrees on either side of any specified direction line allows all pairs to be included regardless of direction. This maximizes the number of pairs in each distance class, which usually gives the "best" or smoothest variogram. See Figure 10-3 in Section 10 for an more detailed illustration of the direction parameters. From this omnidirectional variogram we can usually get the best estimate of the y-intercept (nugget) and maximum value (sill) parameters for the variogram model, as well as the best idea of what type of model(s) should be fitted.

Next, try several different lag intervals for plotting the experimental variograms. You are trying to obtain the maximum detail at small distances, (i.e., small lags) without being misled by structural artifacts due to the particular class interval used. You will have more confidence in a model if it fits experimental variograms computed at several different lag intervals.

The default lag intervals are computed from a rule-of-thumb which states that variograms are generally not valid beyond one-half the maximum distance between samples. The maximum pair distance is therefore divided by two, and then subdivided into ten equal distance classes. Round these to the more convenient numbers of 150 and 15, and plot the resulting variogram (Figure 4-10), as follows:

| OPTION | ACTION | FIELD | VALUE |
|---|---|---|---|
| NEW LAGS | Accept | Minimum | 0 |
| | Input | Maximum | 150 |
| | Input | Increment | 15 |
| EXECUTE | | | |
| PLOT | | | |
| <Q> | | | |



Parameters

File :Example.pcf

Pairs : 1242

Direct.: .000
Tol. : 90.000
MaxBand: n/a

Cadmium Limits

Minimum: .000
Maximum: 16.700

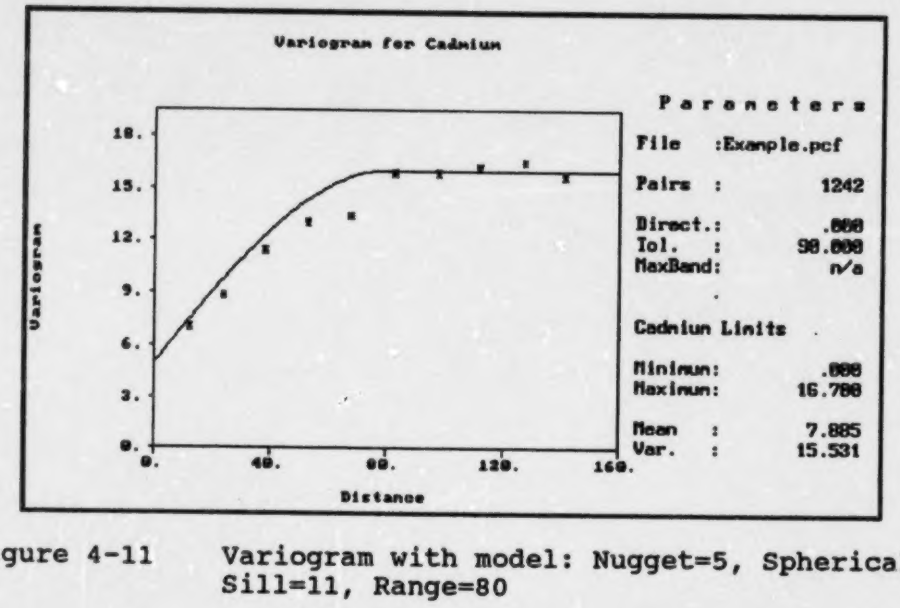
Mean : 7.085
Var. : 15.531

Figure 4-10 Variogram of Cadmium

This variogram shows a well defined structure. Except for the fifth point, which is too low, the shape is typical of a "spherical" model variogram, i.e., an initial linear increase from the Y-intercept curving relatively sharply into a horizontal constant value. The spherical type of variogram is observed frequently in experimental variograms, and is one of the model options available in Geo-EAS. To fit a spherical model to a variogram, you need to estimate the "nugget" or Y-intercept, the "sill" or difference between the nugget and the maximum value, and the "range" or distance at which the model reaches the maximum value. With a little practice, good fits can usually be obtained within two or three tries.

Try an initial model with a nugget of 5, a sill of 11, and a range of 80, using the following option sequence (Note that after variogram model parameters have been entered, the <Left> arrow key can be used to exit the model option). The resulting graph is displayed in Figure 4-11.

| OPTION | ACTION | FIELD | VALUE |
|---|---|---|---|
| MODEL | | | |
| MODEL | Input | Nugget | 5 |
| | Toggle | Type | Spherical |
| | Input | Sill | 11 |
| | Input | Range | 80 |
| PLOT | | | |
| <Q> | | | |



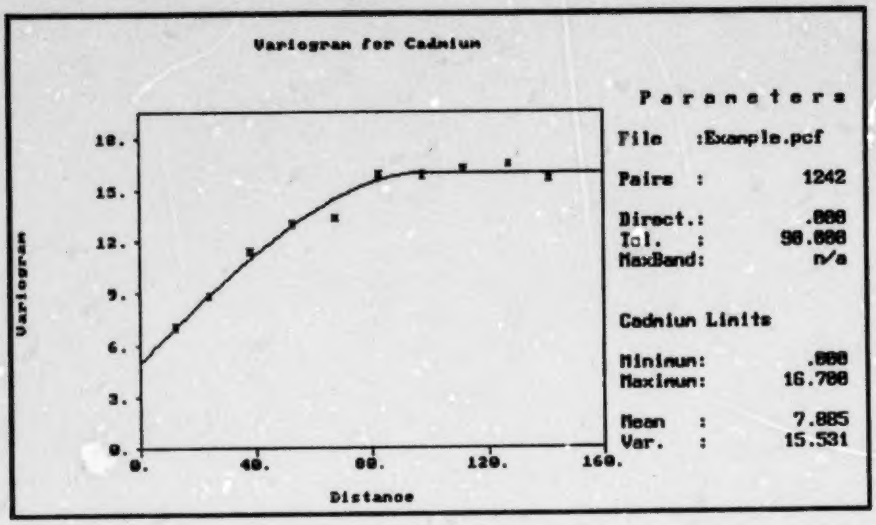
```
Parameters
File    :Example.pcf
Pairs   :          1242
Direct.:           .000
Tol.    :        90.000
MaxBand:            n/a

Cadmium Limits

Minimum:           .000
Maximum:         16.700

Mean    :         7.885
Var.    :        15.531
```

Figure 4-11 Variogram with model: Nugget=5, Spherical, Sill=11, Range=80

This model fits reasonably well at the nugget and sill, but the initial slope is too steep, indicating that the range is too low. It appears that the curve would fit well if it were shifted about 25% to the right, so you should try again with a range of 100:

| OPTION | ACTION | FIELD | VALUE |
|---|---|---|---|
| MODEL | Accept | Nugget | 5 |
|  | Accept | Type | Spherical |
|  | Accept | Sill | 11 |
|  | Input | Range | 100 |
| PLOT |  |  |  |
| <Q> |  |  |  |

The resulting graph is displayed in Figure 4-12.



```
Parameters

File    :Example.pcf

Pairs   :        1242

Direct.:         .000
Tol.    :      90.000
MaxBand:          n/a

Cadmium Limits

Minimum:         .000
Maximum:       16.700

Mean    :       7.885
Var.    :      15.531
```

Figure 4-12    Variogram model: Nugget=5, Spherical, Sill=11, Range=100

This is an excellent fit; about as good as you can get with a spherical model. That low fifth point, however, suggests that an exponential model which has a more gentle curvature may also provide a good fit. (If you are unfamiliar with the four types of models available in VARIO, repeat the option sequence above three more times, changing the model type each time.) A bit of trial and error leads to an exponential model with a nugget of 4.5, sill of 13.5, and range of 160. This graph is displayed in Figure 4-13.

| OPTION | ACTION | FIELD | VALUE |
|---|---|---|---|
| MODEL | Input | Nugget | 4.5 |
|  | Toggle | Type | Exponential |
|  | Input | Sill | 13.5 |
|  | Input | Range | 160 |
| PLOT |  |  |  |
| <Q> |  |  |  |

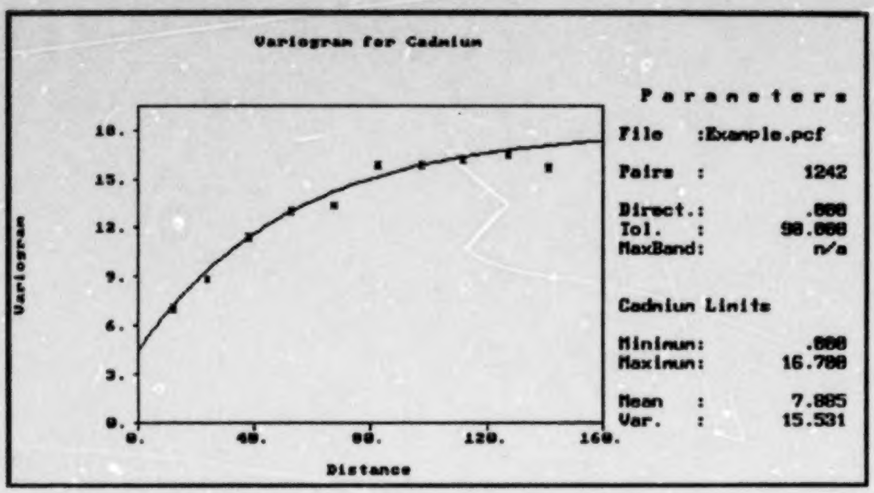


Figure 4-13 Variogram with Exponential model: nugget=4.5, Sill=13.5, Range=160

Some obvious questions that come up at this point are: Which one of these models is best? How do you decide which one to use? What happens if you pick the wrong one? Unfortunately there aren't any simple answers. The best model is the one which most closely matches the true variogram for the site, but of course, you will never know what that is unless you exhaustively sample the site. Although some form of least squares criteria could be used, in Geo-EAS the selection must be made subjectively, simply by picking the model that looks like the best fit. Sometimes the error distributions obtained from cross-validation can help you to decide which. Fortunately, the differences between the spherical and exponential models above will only cause minor differences in the kriged estimates, so that either one would be an acceptable choice.

If you look at variograms computed at different lags, it will become obvious that the experimental variograms contain quite a bit of noise. The shape of the experimental variogram changes as the lag spacing changes, and the model which appears to fit best at one lag spacing may appear to be the worst at another. Try a lag spacing of ten units. The graph of Figure 4-14 will be displayed.

| OPTION | ACTION | FIELD | VALUE |
|---|---|---|---|
| QUIT | | | |
| QUIT | | | |
| NEW LAGS | Accept | Minimum | 0 |
| | Accept | Maximum | 150 |
| | Input | Increment | 10 |
| EXECUTE | | | |
| MODEL | | | |
| PLOT | | | |
| <Q> | | | |

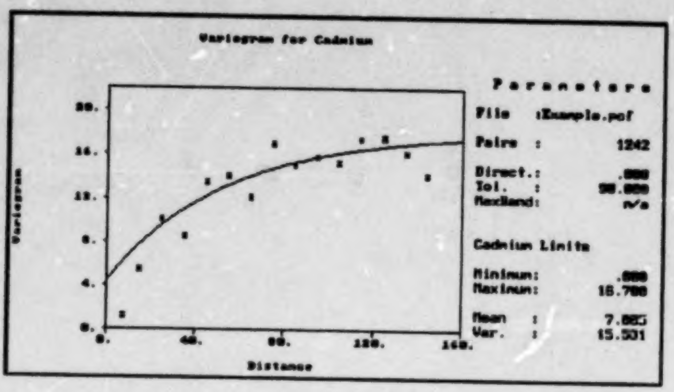


Figure 4-14 Variogram with Exponential Model, Lag Spacing=10

Now repeat the above option sequence with a lag increment of 25. The resulting graph is displayed in Figure 4-15.

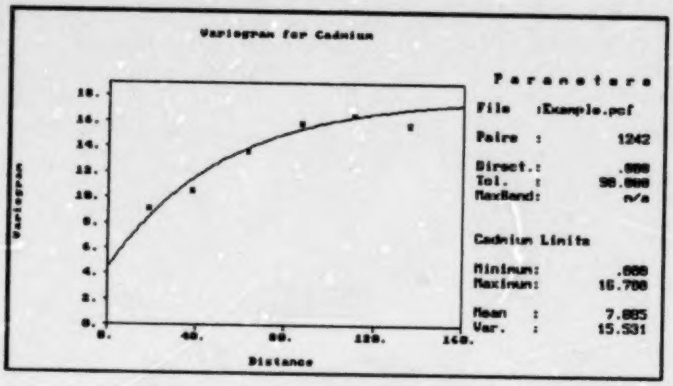


Figure 4-15 Variogram with Exponential Model, Lag Spacing=25

As you can see, the ability to define the "true" variogram structure is limited by the particular set of data available. The best you can do is to find a model which fits reasonably well over a range of lag spacings. Both of the two models proposed earlier are satisfactory. In practice, kriging estimates calculated with the two variogram models will be almost identical. Kriging standard deviations however, are more sensitive than the estimates to changes in the variogram model, as well as to differences between the "real world" and the assumptions underlying the kriging equations. For this reason, it is generally not wise to interpret kriging standard deviations as a true measure of the estimation error. For the remaining discussion of variograms the exponential model will be used.

At this point in the structural analysis, anisotropy is the major remaining question. When you looked at the post plot of the data, there appeared to be a tendency for similar values to form elongated E-W bands. Now you want to see if directional variograms confirm this effect. Like lag spacings, directions and angular tolerances require a trade-off between resolution and precision. If you plot four directional variograms at angles of 0, 45, 90, and 135 degrees, with a tolerance of 22.5 degrees, you have effectively divided the pairs in our omnidirectional variogram into four subsets. This causes an increase in noise comparable to reducing the lag spacing by a factor of four. It is therefore advisable to use a larger lag interval for computing directional variograms. You should use a lag spacing of 25 to compute the four directional variograms listed above, superimposing the omnidirectional exponential model on the plot. Run the option sequence below four times, changing only the direction angle. Figures 4-16 through 4-19 display the directional variograms for 0, 45, 90, and 135 degrees.

| OPTION | ACTION | FIELD | VALUE |
|---|---|---|---|
| QUIT | | | |
| QUIT | | | |
| DIRECTION | Input | Direction | 0 |
| | Input | Tolerance | 22.5 |
| | Accept | Bandwidth | MAX |
| EXECUTE | | | |
| MODEL | | | |
| PLOT | | | |
| <Q> | | | |

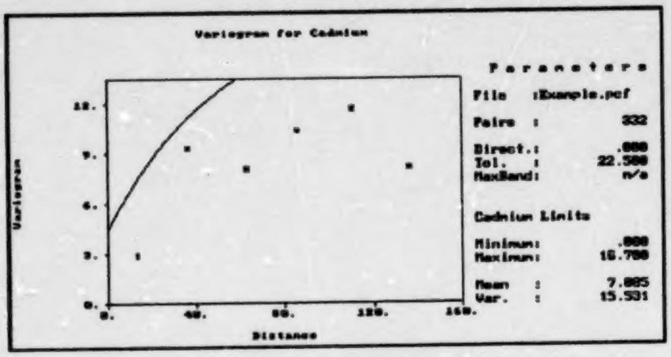


Figure 4-16 Variogram , Exponential Model, Direction = 0

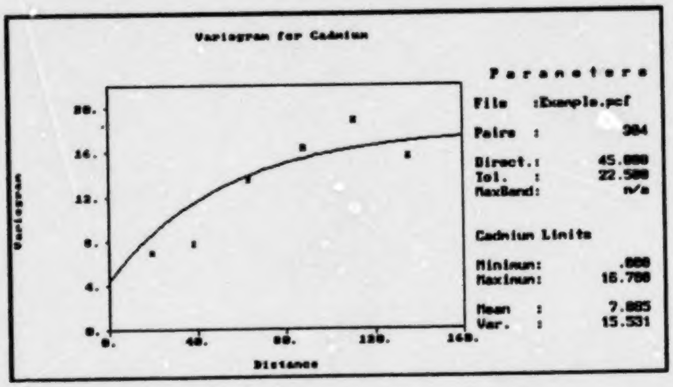


Figure 4-17 Variogram, Exponential Model, Direction=45

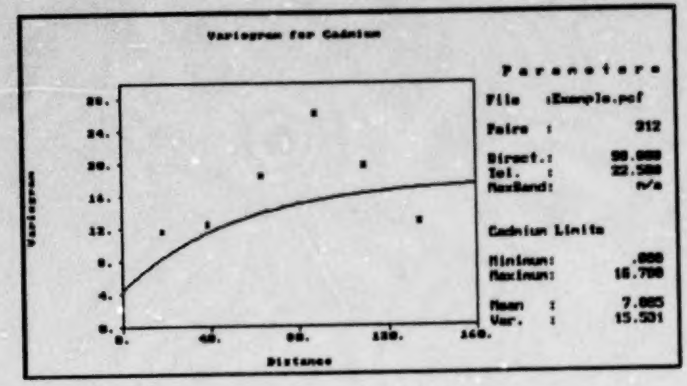


Figure 4-18 Variogram, Exponential Model, Direction=90

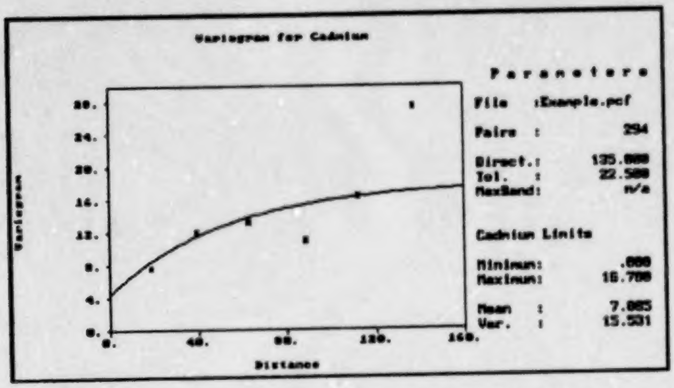


Figure 4-19 Variogram, Exponential Model, Direction=135

These four variograms provide a good illustration of why you usually model the omnidirectional variogram first. In the directional variograms, most of the definition of shape, nugget, and sill has been obscured. You can see, however, a general confirmation of the assumption about the anisotropy. The points on the 0 degree variogram all fall below the omnidirectional model, suggesting the range in that direction should be longer. The opposite is true for the 90 degree variogram, while the 45 and 135 degree variograms are reasonably well fitted by the omnidirectional model. Obviously, one cannot be too precise about fitting ranges to these directional variograms. Likewise, it would not be worthwhile to attempt a more precise definition of the direction of maximum and minimum range.

The program Krige assumes that the directional variogram model ranges form an elliptical pattern. It is therefore only necessary to fit models to the major and minor axis directions to define the entire 2-D structure. One could make a case for the range of the major axis (0 degrees) of the exponential model being anywhere between 250 and 400 units, and the major axis (90 degrees) being between 60 and 120 units. We will settle on a model with major and minor axes of 300 and 100 units, respectively, and move on to kriging.

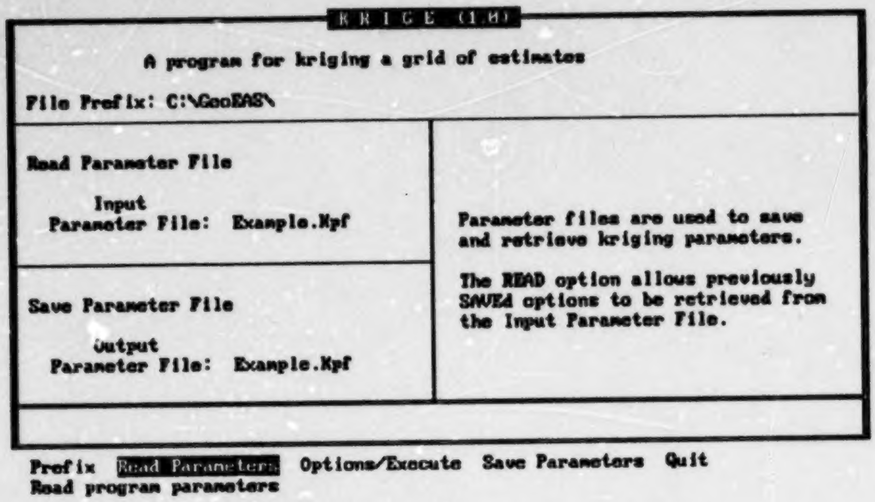
A note on alternate types of variograms -- The Type option on the Variogram Results screen allows you to select and plot any of three alternate estimators of spatial variability. These are sometimes less sensitive to outliers, skewed distributions, or clustered data than ordinary variograms and may help you recognize a structure when the ordinary variogram is too noisy. The relative variogram is analogous to the relative standard deviation often used to measure analytical variability. The "mad'ogram" plots the mean absolute differences. The non-ergodic variogram is a relatively new method (Srivastiva, 1987) based on estimates of covariance rather than variance. Non-ergodic variograms have the same units (measurement units squared) as ordinary variograms and may be modeled and used for kriging in the same way. Relative variograms are unitless (decimal fraction squares). When modeled and used for kriging the relative kriging standard deviations must be multiplied by the estimated values to be comparable with kriging standard deviations produced with ordinary variogram models. Madograms are not "true variograms" because they are not based upon squared differences. In general, kriging with madogram models is not recommended.

## 4.4 KRIGING AND CONTOURING

The program Krige produces a regular grid of interpolated point or block estimates using either "Ordinary" or "Simple" kriging. The default option, ordinary block kriging, is recommended for most environmental applications. Point kriging usually provides estimates very similar to those from block kriging, but if a point being estimated happens to coincide with a sampled location, the estimate is set equal to the sample value. This is not appropriate for contour mapping, which implicitly requires a spatial estimator. Ordinary kriging estimates the point or block values with a weighted average of the sample values within a local search neighborhood, or ellipse, centered on the point or block. Simple kriging also assigns a weight to the population mean, and is in effect making a strong assumption that the mean value is constant over the site; it also requires that the available data be adequate to provide a good estimate of the mean.

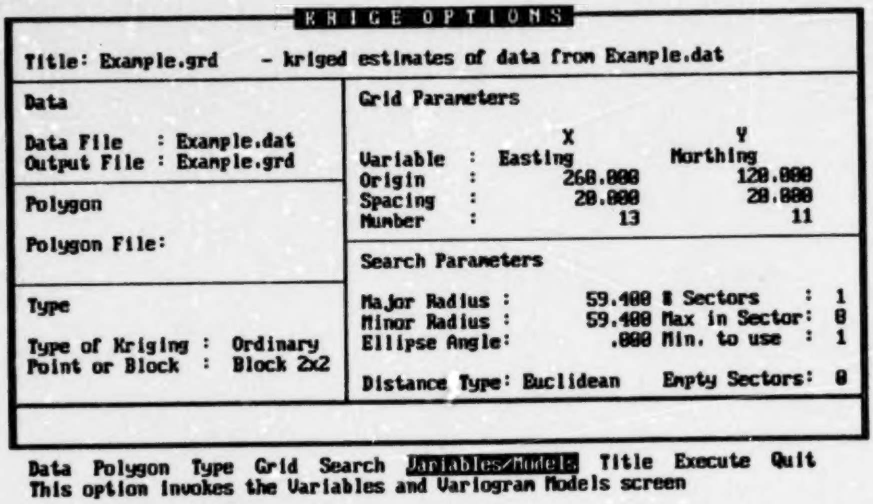
In order to execute Krige we must provide the names of the data file and an output grid file, and we must select a variable and enter a variogram model. The program computes a default 10x10 grid, which we will usually want to override with more convenient "round" numbers. The default search ellipse is a circle with a radius about one fourth the maximum x or y dimension of the site, which should be adequate for most cases. The purpose of the search is to reduce computation time by eliminating from the kriging system of equations those samples which are unlikely to get "significant weights". The default search strategy is to treat the search circle as a single "sector", to examine all samples within it and use at least one, but not more than the closest eight. The number of samples required for kriging is related to the value of the nugget term in the variogram compared to the maximum variogram value possible within the search area. The higher the nugget, the more likely that more distant samples will get significant weights. A rough rule of thumb would be to use eight samples when the nugget is near zero, increasing to twenty when the nugget is more than 50% of the maximum value. The more complex sector search options may be useful when you have unusual patterns or clusters of data. We will accept the default search for now, and check during kriging to see how well it works. Initiate program Krige, and the main screen will be displayed (Figure 4-20).

The Krige main menu allows you to retrieve previously saved kriging parameters, or to save the parameters you have just used before exiting the program. Because this is your first attempt with this data set, you must use the Options/Execute option to go directly to the Options screen and menu. This screen is displayed in Figure 4-21.



```
                          K R I G E  (1.0)
            A program for kriging a grid of estimates
File Prefix: C:\GeoEAS\

Read Parameter File
      Input
  Parameter File:  Example.Kpf          Parameter files are used to save
                                        and retrieve kriging parameters.

Save Parameter File                     The READ option allows previously
                                        SAVEd options to be retrieved from
      Output                            the Input Parameter File.
  Parameter File:  Example.Kpf

Prefix  Read Parameters  Options/Execute  Save Parameters  Quit
Read program parameters
```

Figure 4-20 Krige Main Screen

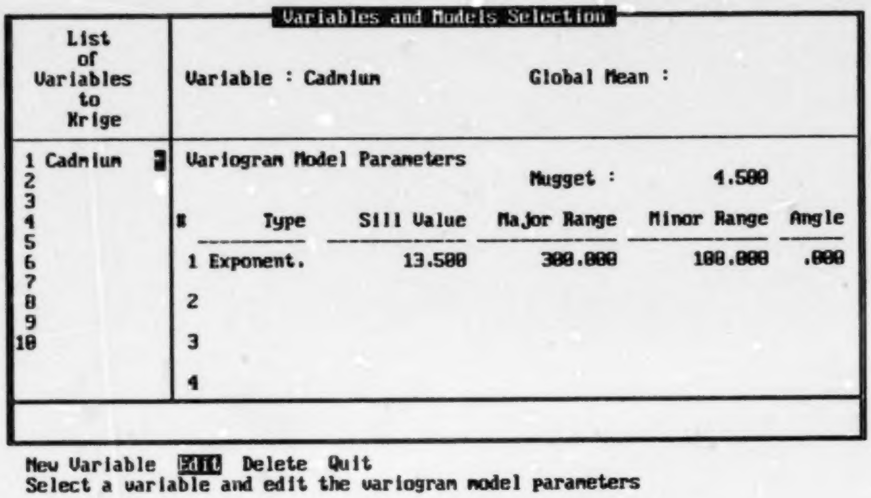


```
                          K R I G E   O P T I O N S
Title: Example.grd    - kriged estimates of data from Example.dat
Data                          Grid Parameters
                                               X               Y
Data File   : Example.dat     Variable  :  Easting         Northing
Output File : Example.grd     Origin    :        260.000         120.000
                              Spacing   :         20.000          20.000
Polygon                       Number    :             13              11

Polygon File:                 Search Parameters

Type                          Major Radius :        59.400 # Sectors    :  1
                              Minor Radius :        59.400 Max in Sector:  0
Type of Kriging :  Ordinary   Ellipse Angle:          .000 Min. to use  :  1
Point or Block  :  Block 2x2
                              Distance Type: Euclidean    Empty Sectors:  0

Data  Polygon  Type  Grid  Search  Variables/Models  Title  Execute  Quit
This option invokes the Variables and Variogram Models screen
```

Figure 4-21 Krige Options Screen

Use the following option sequence to specify the file names and grid parameters, and to proceed to the next menu (Figure 4-22):

| OPTION | ACTION | FIELD | VALUE |
|---|---|---|---|
| OPTIONS/EXECUTE | | | |
| DATA | Accept | Data File | Example.dat |
| | Accept | Grid File | Example.grd |
| GRID | Accept | X variable | Easting |
| | Accept | Y variable | Northing |
| | Input | X origin | 260 |
| | Input | Y origin | 120 |
| | Input | X cell size | 20 |
| | Input | Y cell size | 20 |
| | Input | X # cells | 13 |
| | Input | Y # cells | 11 |
| VARIABLES/MODELS | | | |



```
                    Variables and Models Selection
    List
     of
 Variables     Variable : Cadmium             Global Mean :
     to
   Krige

 1 Cadmium     Variogram Model Parameters
 2                                        Nugget :        4.500
 3
 4             #      Type    Sill Value  Major Range  Minor Range  Angle
 5
 6              1 Exponent.       13.500      300.000      100.000   .000
 7
 8              2
 9
10              3

                4

 New Variable  Edit  Delete  Quit
 Select a variable and edit the variogram model parameters
```

Figure 4-22    Krige Variables/Models Screen

The following option sequence selects Cadmium as the variable to be kriged, enters the variogram model, executes the kriging routine, and saves the parameter file:

| OPTION | ACTION | FIELD | VALUE |
|---|---|---|---|
| NEW VARIABLE | Toggle | Variable | Cadmium |
| | Input | Nugget | 4.5 |
| | Toggle | Type | Exponential |
| | Input | Sill value | 13.5 |
| | Input | Major range | 300 |
| | Input | Minor range | 100 |
| | Accept | Angle | 0 |
| QUIT | | | |
| EXECUTE | | | |
| <Q> | | | |
| QUIT | | | |
| SAVE PARAM. | Accept | Parameter file | Example.kpf |

Upon selection of the Execute option, the program first displays a color-coded sample location map on the screen, and then overlays this with a color-coded/shaded grid cell as each kriged estimate is computed. At the bottom of the screen, a summary line for each estimate is displayed. As you watch this proceed, you may note that the number of samples being used is only less than the specified 8 for the exterior blocks of the grid, indicating that the default search radii are adequate to obtain 8 neighbors. You can use the "debug" options during the kriging computations to help you understand what is actually happening in the program, and to decide whether you need to change the search options. Activating <caps-lock> provides you with a map showing the search ellipse and the samples selected for kriging the current block. The goal of the search is to include all of the samples which are relevant to the estimate, while avoiding spending a lot of time computing negligible weights for samples that do not matter. The <num-lock> key lets you look at a list of the selected samples' coordinates, distances from the block center, and kriging weights. Use <enter> to continue to subsequent displays.

Given that sample weights must sum to 1.0, it seems reasonable to conclude that samples with weights of less than 0.01 can be neglected without significantly affecting the kriging results. The goal of your search would therefore be to consistently find a set of samples such that the lowest two or three weights would be at or just below 0.01. When you examine the lists of weights for a number of blocks during this run, you find the lowest weights to generally be in the range of 0.02 or 0.03. This is not really bad, but it might have been better to raise the maximum number of samples to 10 or 15 (and increase the search radii, if necessary).

The kriged results have been written to the file Example.grd. Proceed to contour this grid of kriged values using the program Conrec. First initiate Conrec, and use the following option sequence. The resulting graph is displayed in Figure 4-23.

| OPTION | ACTION | FIELD | VALUE |
|---|---|---|---|
| OPTIONS/EXECUTE | | | |
| DATA | Accept | Data File | Example.grd |
| | Accept | X variable | Easting |
| | Accept | Y variable | Northing |
| | Accept | Contour variable | *Cadmium |
| | Answer | | Y |
| EXECUTE | Accept | Metafile | Metacode.met |
| <Q> | | | |

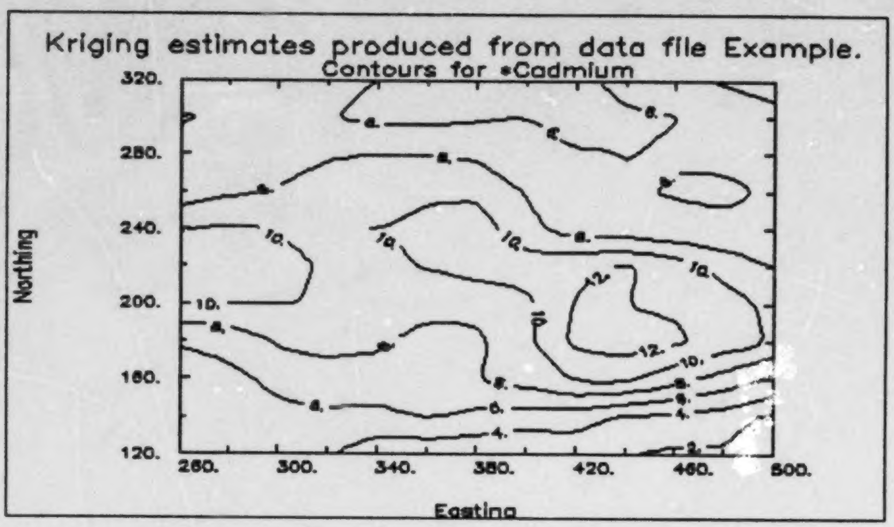


Figure 4-23 Contours for Cadmium Kriging Estimates

The final option sequence below plots a contour map of the kriging standard deviations or estimation errors (Figure 4-24), and demonstrates some of the options in Conrec:

| OPTION | ACTION | FIELD | VALUE |
|---|---|---|---|
| OPTIONS/EXECUTE | | | |
| VARIABLES | Accept | X variable | Easting |
| | Accept | Y variable | Northing |
| | Accept | Contour variable | KSDCadmium |
| | Answer | | Y |
| CONTOUR OPTIONS | | | |
| NEW LEVELS | Accept | Starting Value | 1 |
| | Accept | Maximum Value | 3 |
| | Input | Cont. Increment | 0.25 |
| DASH PATTERN | Input | Dash Pattern | --    -- |
| | Input | Dash Cutoff | 1.9 |
| | Accept | # Rep/Label | 5 |
| QUIT | | | |
| EXECUTE | Accept | Metafile | Metacode.met |
| <Q> | | | |
| QUIT | | | |
| QUIT | | | |

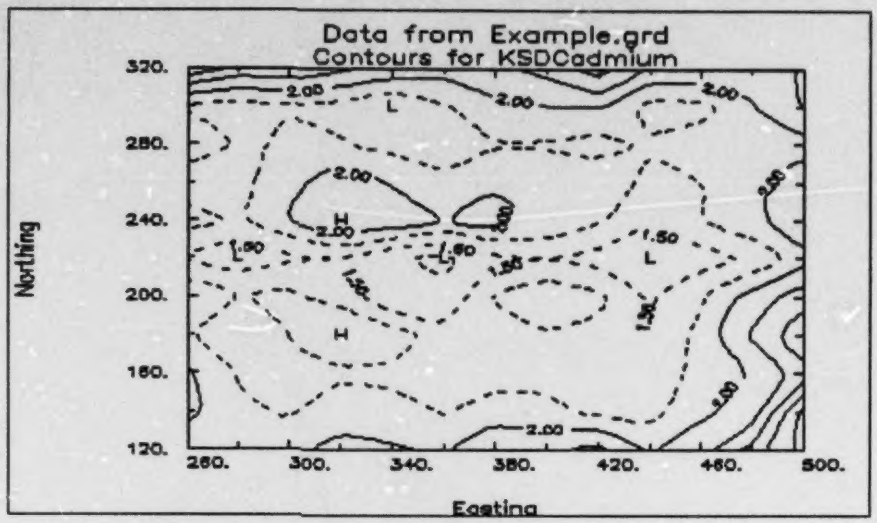

Data from Example.grd
Contours for KSDCadmium
Northing
Easting
320.
280.
240.
200.
160.
120.
260.
300.
340.
380.
420.
460.
500.
2.00
1.50
H
L

Figure 4-24 Contours for Cadmium Kriging Standard Deviations

This map illustrates the reasonable result that the highest kriging errors are predicted in areas with the lowest density of sample data.

## 4.5 SUMMARY AND EXERCISES

The example exercise just completed contained the basic elements of any geostatistical study. You started with a sample data set, conducted an exploratory statistical analysis, interpreted the spatial correlation structure of the data and inferred an underlying variogram model, and used the model to interpolate a grid of kriged estimates. In the process you had to make a number of "judgment calls" which affected the results. You treated the data set as representing a single population. You chose not to delete any outliers. You chose to represent the spatial correlation structure of the data with an anisotropic exponential model plus a nugget term. You accepted the default kriging option of ordinary block kriging (with blocks approximated by a 2x2 grid of points). Finally, a conclusion was drawn that the default maximum of 8 samples in the kriging program should be increased.

Readers with little or no previous experience in geostatistical analysis may not feel comfortable with this entire process. It is not always obvious which of these factors are most significant and which if any can be ignored. Nor is it easy to define the point at which to conclude that you have done the best you can, given the quality and quantity of data. The best remedy for this situation is practice: Rerun KRIGE with Example.dat, using various combinations of the variogram model, search strategy, kriging type, grid size, etc., until you get a feel for how these factors interact. The two exercises below suggest ways of comparing the results from different kriging options, and also utilize some of the other Geo-EAS programs.

### EXERCISE 1 - Compare Anisotropic vs. Isotropic variograms

Step 1. Run Trans to read Example.dat and write a new file named Compare.dat. Use the Create option to create a new variable Cd1 equal to the old variable Cadmium (by adding a constant 0 to the variable Cadmium). This step will help to avoid the problem of creating two kriged variables with the same name. Repeat the process for another new variable Cd2. Delete the variables Arsenic, Cadmium, and Lead, and save the result in Compare.dat.

Step 2. Run Krige with the data file Compare.dat to create a file of kriged estimates called Compare.grd. Krige both variables Cd1 and Cd2 in the same run. Krige Cd1 with the anisotropic exponential variogram model you just used in the example. Krige Cd2 with the equivalent isotropic model (major and minor ranges both equal 160).

Step 3. Run Trans with the grid file Compare.grd to create a new variable called *Cd1-*Cd2. Save the results back into Compare.grd.

Step 4. Run Conrec with the grid file Compare.grd to plot contour maps of *Cd1, *Cd2, and *Cd1-*Cd2.

Step 5. Run Scatter with the grid file Compare.grd to plot *Cd1 vs. *Cd2.

Step 6. Run Stat1 with the grid file Compare.grd to plot histograms of *Cd1, *Cd2, and *Cd1-*Cd2.

**EXERCISE 2 - Compare Point vs. Block kriging**

Step 1. Run Krige with the data file Compare.grd to create a grid file of kriged estimates called Comp1.grd. Use the isotropic exponential model, and krige Cd1 with ordinary point kriging.

Step 2. Repeat Step 1 with a grid file called Comp2.grd. Krige Cd2 with ordinary block kriging (2x2), keeping all other parameters the same.

Step 3. Run Dataprep to merge Comp2.grd into Comp1.grd.

Step 4. Repeat Steps 3-6 from Exercise 1, using Comp1.grd

These exercises can be repeated to make other interesting comparisons. For example, compare the results of kriging with a variogram model consisting of only a nugget term vs. a spherical or exponential model with zero nugget. Or compare kriging with a maximum of 4 samples vs. 20 samples, all other parameters being equal.

# SECTION 5

# DATAPREP

## 5.1 WHAT DATAPREP DOES

Dataprep provides utilities for Geo-EAS data files. Dataprep has two divisions, the DOS Utilities and the File Operations. The DOS Utilities allows access to commonly used DOS commands. The File Operations include utilities to manipulate Geo-EAS data files.

The Dataprep File Operations use temporary files called Scratch Files for storing data read from a Geo-EAS data file and for processing. The Append and Merge operations require an additional temporary file for processing. The temporary files are called ZZSCTCH1.FIL and ZZSCTCH2.FIL. Each time an operation is executed the temporary files are generated and then deleted after processing is complete.

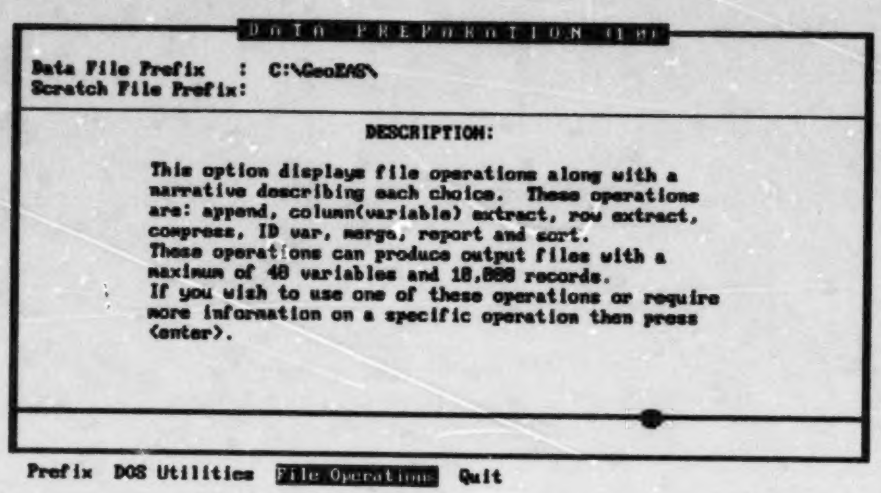
## 5.2 DATA LIMITS

Dataprep reads and generates Geo-EAS data files containing a maximum of 48 variables and 10,000 samples. If a file should contain more than 10,000 samples then only the first 10,000 samples are read and a warning message is displayed. The file operations will generate output data files containing up to 10,000 samples. If a file operation should generate an output data file requiring more than 10,000 samples then only the first 10,000 samples are written. In such a case no warning messages are displayed.

## 5.3 THE MENU HIERARCHY

```
Dataprep-- Prefix
         | DOS Utilities ---- Directory -------- Directory
         |                  |                  | Execute
         |                  |                  \ Quit
         |                  | Print ------------ File
         |                  |                  | Execute
         |                  |                  \ Quit
         |                  | List ------------- File
         |                  |                  | Execute
         |                  |                  \ Quit
         |                  | Copy ------------- Files
         |                  |                  | Execute
         |                  |                  \ Quit
         |                  | Rename ----------- Files
         |                  |                  | Execute
         |                  |                  \ Quit
         |                  | Delete ----------- File
         |                  |                  | Execute
         |                  |                  \ Quit
         |                  | DOS Command
         |                  \ Quit
         |
         | File Operations -- Append------------ Files
         |                  |                  | Execute
         |                  |                  \ Quit
         |                  | Column Extract---- Files
         |                  |                  | Variables
         |                  |                  | Execute
         |                  |                  \ Quit
         |                  | Row Extract------- Files
         |                  |                  | Subsetting Condition
         |                  |                  | Execute
         |                  |                  \ Quit
         |                  | Compress---------- Files
         |                  |                  | Execute
         |                  |                  \ Quit
         |                  | ID Variable------- Files
         |                  |                  | Execute
         |                  |                  \ Quit
         |                  | Merge------------- Files
         |                  |                  | Execute
         |                  |                  \ Quit
         |                  | Report------------ Files
         |                  |                  | Variables
         |                  |                  | Execute
         |                  |                  \ Quit
         |                  | Sort-------------- Files
         |                  |                  | Variable
         |                  |                  | Execute
         |                  \ Quit             \ Quit
         \ Quit
```

## 5.4 THE MAIN MENU



```
Data File Prefix   :  C:\GeoEAS\
Scratch File Prefix:

                        DESCRIPTION:

      This option displays file operations along with a
      narrative describing each choice.  These operations
      are: append, column(variable) extract, row extract,
      compress, ID var, merge, report and sort.
      These operations can produce output files with a
      maximum of 40 variables and 10,000 records.
      If you wish to use one of these operations or require
      more information on a specific operation then press
      <enter>.
```

Figure 5-1     Dataprep Main Screen

The Main screen and menu (Figure 5-1) provides options which allow you to access the DOS Utilities and File Operations menus. The menu line appears as follows:

```
Prefix  DOS Utilities  File Operations  Quit
```

### Prefix

The Prefix option is used to enter the prefix strings for the data file and the scratch file.

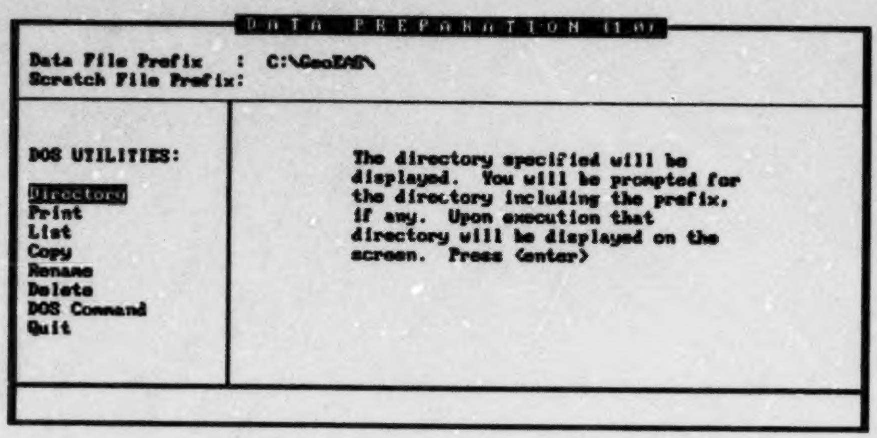
### DOS Utilities

The DOS Utilities option provides access to the DOS Utilities menu. The DOS Utilities menu provides access to the DOS commands such as Directory, Print, List (same as the DOS "MORE" command), Copy, Rename, and Delete. Refer to your DOS manual for further information on these DOS commands. The DOS Utilities menu is discussed below.

### File Operations

The File Operations option provides access to the File Operations menu. The File Operations menu provides the following file operations: Append, Column (variable) extract, Row extract, Compress, ID Variable, Merge, Report and Sort. The File Operations menu is discussed below.

## 5.5 THE DOS UTILITIES MENU



Data File Prefix : C:\GeoEAS\
Scratch File Prefix:

The directory specified will be displayed. You will be prompted for the directory including the prefix, if any. Upon execution that directory will be displayed on the screen. Press <enter>

Figure 5-2 Dataprep DOS Utilities Screen

The DOS Utilities screen and menu (Figure 5-2) provides commonly used DOS commands. These commands operate just as the DOS commands do. Refer to your DOS manual for further information. To select an option from the vertical menu, use the <up> or <down> arrow key (not the <left> or <right> arrow key) to position the cursor bar then press the <enter> key.

**Directory**

Upon selection of this option the Directory menu is displayed. The Directory menu provides the options necessary to list all directory entries or only those for specified files. The directory option is similar to the DOS command "Dir". The menu line appears as follows:

```
Directory  Execute
```

**Directory** - This option results in a prompt for a character string. The string can be either a directory or file name. The string is entered into an alphanumeric field that is 55 characters long. If the field is left blank then the current directory is used by default.

**Execute** - Selection of this option causes the directory to be displayed on a new screen. An error message appears if the directory is non-existent. After the directory is listed the message "Press <enter> to return to menu" is displayed. The <enter> key returns control to the Directory menu.

**Print**

Upon selection of this option the Print menu is displayed. The Print menu provides the options necessary to print a file. The Print option is similar to the DOS command "Print". The menu line appears as follows:

```
Files  Execute  Quit
```

**Files** - Upon selecting this option, you are prompted for the name of the file that is to be printed.

**Execute** - Selection of this option causes the specified file to be printed. A yes/no prompt appears asking if the printer is ready. If yes is indicated then the DOS Print command is executed. When printing begins the Print menu screen is displayed and a message appears indicating that the file is being printed.

**List**

Upon selection of this option the List menu is displayed. The List menu provides the options necessary to list a file. The List option is similar to the DOS command "More". The menu line appears as follows:

```
File  Execute  Quit
```

**File** - You will be prompted for the name of the file that is to be listed.

**Execute** - Upon selection of this option DOS executes the "More" command. The screen is cleared and the contents of the file are displayed. When the screen is filled the message "More" appears on the last line. The <enter> key causes another page of the file's contents to be displayed. After the entire file has been listed, press <enter> to display the List menu screen and control is returned to the List menu.

**Copy**

Upon selection of this option the Copy menu is displayed. The Copy menu provides the options necessary to copy a file. The menu line appears as follows:

```
Files  Execute  Quit
```

**Files** - You are prompted for two file names. Upon execution, the contents of the first data file are copied over to the second data file.

**Execute** - Upon selection of this option DOS executes the "Copy" command. When the file has been copied a message is displayed. An error message appears whenever the "Copy " command could not be successfully executed.

**Rename**

Upon selection of this option the Rename menu is displayed. The Rename menu provides the options necessary to rename a file. The menu line appears as follows:

```
Files  Execute  Quit
```

**Files** - You are prompted for two file names. The name of the file specified first is renamed to the second file name given. If a data file exists with the second file name, then an error message appears.

**Execute** - Upon selection of this option, DOS executes the "Rename" command. A message stating that the file has been renamed appears after the process is complete.

**Delete**

Upon selection of this option the Delete menu will be displayed. The Delete option uses the DOS command "Del". The menu line appears as follows:

```
File  Execute  Quit
```

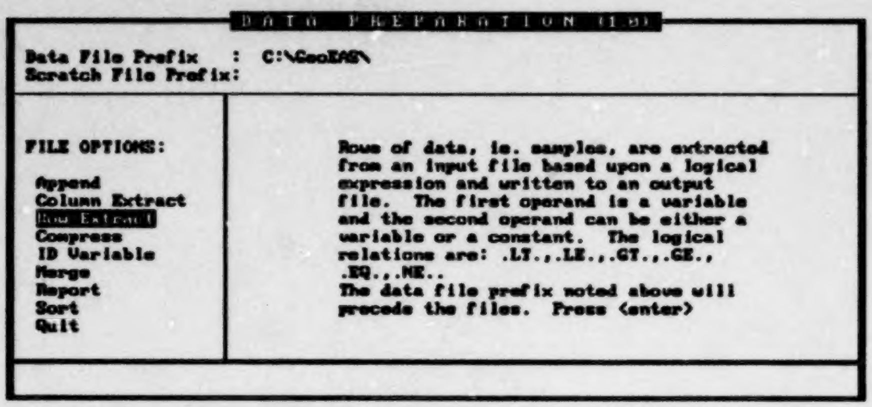
**File** - You will be prompted for the name of the file to be deleted.

**Execute** - Upon selection of this option, DOS executes the "Delete" command. After the file has been deleted an informative message is displayed.

**DOS Command**

Upon selection of this option you will access DOS. To return to Dataprep type the command "**Exit <enter>**".

## 5.6 THE FILE OPERATIONS MENU



Data File Prefix   :  C:\GeoEAS\
Scratch File Prefix:

Rows of data, ie. samples, are extracted from an input file based upon a logical expression and written to an output file. The first operand is a variable and the second operand can be either a variable or a constant. The logical relations are: .LT.,.LE.,.GT.,.GE., .EQ.,.NE.. The data file prefix noted above will precede the files. Press <enter>

Figure 5-3     Dataprep File Operations Screen

The File Operations screen and menu (Figure 5-3) provides a set of useful operations for manipulating Geo-EAS data files. To select an option from the vertical menu, use <up> or <down> (not <left> or <right>) to position the cursor, and press <enter> to select the option. The two Geo-EAS input data files called Demo1.dat and Demo2.dat are used to demonstrate each file operation discussed below.

```
Demo1.dat - ficticious data set 1
    3
Easting   feet
Northing  feet
Arsenic   ppm
   320.0  311.0    .850
   119.0  119.0    .630
   115.0  111.0    .560
   114.0  269.0   1.020
   114.0  269.0   1.020
   431.0  137.0    .67
```

```
Demo2.dat - ficticious data set 2
    3
Easting   feet
Northing  feet
Lead      ppm
   102.0  164.0    .300
   122.0  137.0    .360
   116.0  119.0    .700
   150.0  315.0    .500
   148.0  291.0    .710
```

**Append**

Upon selection of this option the Append menu will be displayed. The Append menu provides the options necessary to append two Geo-EAS data files. A discussion on the append operation follows in the Execute option. The menu line appears as follows:

```
Files  Execute  Quit
```

**Files** - You are prompted for three Geo-EAS data file names. Upon execution the second file name specified is appended to the first file name entered. The first and second file names cannot be the same. If they are then an error message appears. The third file name entered is the name of the output file.

**Execute** - Upon selection of this option, Dataprep will append the second file to the first file and store the results in the output file. After the operation is complete the output variables are displayed on the screen and a message is displayed. Upon pressing any key, control is returned to the Append menu. A discussion of the Append operation follows:

Assume the first input file will be called File1 and the second input file called File2. Variables that exist in both input files (i.e. have identical variable names) will be combined into one variable with the records of File1 preceding those of File2. The difference is that for File1 variables the records normally occupied by File2 variables are filled with missing values(1.E+31). For File2 variables the records normally occupied by File1 variables are filled with missing values. As an example the output file Out1.dat was generated when Demo1.dat (above) as File1 and Demo2.dat (above) as File2 were appended. Out1.dat is shown below.

Out1.dat

```
Demo1.dat  - ficticious data set 1
   4
Easting    feet
Northing   feet
Arsenic    ppm
Lead       ppm
   320.0   311.0   .850        .10E+32
   119.0   119.0   .630        .10E+32
   115.0   111.0   .560        .10E+32
   114.0   269.0   1.02        .10E+32
   114.0   269.0   1.02        .10E+32
   431.0   137.0   .670        .10E+32
   102.0   164.0   .10E+32     .300
   122.0   137.0   .10E+32     .360
   116.0   119.0   .10E+32     .700
   150.0   315.0   .10E+32     .500
   148.0   291.0   .10E+32     .710
```

## Column Extract

Upon selection of this option the Column Extract menu is displayed. The Column Extract menu provides the options necessary to create a Geo-EAS data file with variables extracted from an input file. The menu line appears as follows:

```
Files  Variables  Execute  Quit
```

**Files** - This option is used to specify two file names. The first, an input file, is a Geo-EAS data file. The second file is a Geo-EAS output file.

**Variables** - This option is used to specify one or more variables which will be extracted and written to the output file when the Execute option is selected. The variables are selected from a toggle field. After each selection, the variable name is displayed on the screen and a yes/no prompt appears asking if you want to select another variable. If yes is indicated then you are prompted for another variable. If no is indicated then control is returned to the Column Extract menu.

**Execute** - Upon selection of this option, the selected variables and related data are copied and stored in the output file. When the operation is complete, a message is displayed. Upon pressing any key, control is returned to the Column Extract menu.

## Row Extract

Upon selection of this option the Row Extract menu is displayed. The Row Extract menu provides the options necessary to perform row extraction. This operation extracts samples from the specified input Geo-EAS data file based upon a test condition. The menu line appears as follows:

```
Files  Subsetting Condition  Execute  Quit
```

**Files** - This option is used to specify two files. The name of first file entered, an input file, is a Geo-EAS data file. The name of the second file entered is an output file.

**Subsetting Condition** - This option is used to specify a test condition. The test condition is of the form <Operand1> <Relation> <Operand2>, where <Operand1> is a variable and <Operand2> can be a variable or a constant. <Relation> can be:

.LT., .LE. - Less than, Less than or equal to
.GT., .GE. - Grater than, Greater than or equal to
.EQ., .NE. - Equal to, Not equal to

Upon selection of the Subsetting Condition option the variable names stored in the input file are displayed. You are prompted for a variable for the Operand1 from a toggle field. After the selection you are prompted for a logical operator from the toggle field. After this selection, control is passed to the Row Extract Operand menu. The Row Extract Operand menu is the next menu discussed. After a selection is made for the second operand, control is returned to the Row Extract menu.

The Row Extract Operand menu provides the options necessary to select a variable or enter a constant for Operand2. The menu line appears as follows:

```
Constant  Variable
```

**Constant** - This option is used to specify a constant(floating point) number for Operand2. The constant is entered into a numeric field. If a constant causes a numeric overflow, then a message appears informing you of the error (pressing any key returns control to the Row Extract Operand menu). After a valid constant has been entered, pressing <enter> returns control to the Row Extract menu.

**Variable** - This option is used to specify a variable for the Operand2. The variable is selected from a toggle field. After the selection, pressing <enter> returns control to the Row Extract menu.

**Execute** - When selecting the Execute option, the Row Extraction process is initiated. Each sample of Operand1, described above, is checked to see if it satisfies the test condition. If so then that entire line of data is extracted from the input data file and stored in a temporary file. After this process is complete, the data from the temporary file are stored in the output file. When the data have been stored to the output file and the execution complete, you are informed with a message stating that the data has been sent to the output file. If no samples satisfy the test condition, then a message appears and no data are stored. In both cases, pressing any key returns control to the Row Extract menu.

As an example of the Row Extraction operation, the following output data file, Out2.dat, is generated when Demo1.dat is the specified input file and the test condition is: Easting .LE. Northing.

Out2.dat

```
Demo1.dat - ficticious data set 1
   3
Easting   feet
Northing  feet
Arsenic   ppm
   119.0      119.0      .630
   114.0      269.0      1.02
   114.0      269.0      1.02
```

Each data record in Demo1.dat is examined by the program. If the test condition is true, then that line in the file is extracted and stored in the specified output file. Only those records satisfying the specified logical expression will be extracted and stored in the output file.

## Compress

Upon selection of this option the Compress menu is displayed. The Compress menu provides the options necessary to compress a Geo-EAS data file. This operation eliminates any duplicate data records that appear in a specified input Geo-EAS data file and stores the results in the specified output Geo-EAS data file. An example is shown in the Execute option. The menu line appears as follows:

```
Files  Execute  Quit
```

**Files** - This option is used to specify two data file names. The first, an input file, is a Geo-EAS data file. The second is an output file. After the two files have been specified, the variable names stored in the input file are displayed.

**Execute** - Upon selection of this option, the data from the input file are stored in a temporary file. Duplicate records are deleted and the data are stored in the specified output file. When the entire process is complete, a message stating that the data have been sent to the output file is displayed. Upon pressing any key, control is returned to the Compress menu.

As an example of the Compress operation, the following output file, Out5.dat, was generated when the input file, Demo1.dat, was compressed. Out5.dat follows.

Out5.dat

```
Demo1.dat - ficticious data set 1
   3
Easting    feet
Northing   feet
Arsenic    ppm
   320.0     311.0      .850
   119.0     119.0      .630
   115.0     111.0      .560
   114.0     269.0      1.02
   431.0     137.0      .670
```

Note that all duplicate records have been deleted.

**ID Variable**

Upon selection of this option the ID Variable menu is displayed. The ID Variable menu provides the options to create the variable "Sequence #". The Sequence # denotes the sequential position of the data in the input file. An example of this is shown in the Execute option. The menu line appears as follows:

```
Files  Execute  Quit
```

**Files** - This option is used to specify two Geo-EAS data file names. The first is an input data file. The second is an output file. After the two files have been specified, the variable names stored in the input file are displayed.

**Execute** - This option appends a variable called "Sequence #" to the current listing of variables displayed on the screen. The variable name "Sequence #" is appended to the variable names read from the input file. These variable names are then stored in the specified output file. An example of such an output file is Out6.dat.

Out6.dat

```
Demo1.dat - ficticious data set 1
    4
Easting   feet
Northing  feet
Arsenic   ppm
Sequence #
     320.0      311.0     .850       1.
     119.0      119.0     .630       2.
     115.0      111.0     .560       3.
     114.0      269.0     1.02       4.
     114.0      269.0     1.02       5.
     431.0      137.0     .670       6.
```

## Merge

Upon selection of this option the Merge menu is displayed. The Merge menu provides the options necessary to merge two Geo-EAS data files. The details of this operation are discussed in the Execute option. The menu line appears as follows:

```
Files  Execute  Quit
```

**Files** - This option is used to specify the names of two Geo-EAS data files which are to be merged, and the name of an output file, which will contain the results. The files to be merged cannot have the same file name, or an error message appears.

**Execute** - When this option is selected, the Merge process is initiated. After this process is complete the variables from the output file are displayed and a message indicating that the data have been sent to the output file appears. Pressing any key returns control to the Merge menu. To describe the merge process, assume that File1 is the first file name entered and File2 is the second file name entered. If one input file is smaller than the other input file, then the smaller file has missing values added to its variables. Variables that appear in both input File1 and input File2 are combined with the samples of File1 preceding those of File2. The specified output file stores the results of the merged files. An example best demonstrates the merge operation. The output file, Out3.dat, which follows, displays the merging of input files Demo1.dat as File1 and Demo2.dat as File2.

Out3.dat

```
Demo1.dat - ficticious data set 1
    4
Easting   feet
Northing  feet
Arsenic   ppm
Lead      ppm
    320.0    311.0     .850       .300
    119.0    119.0     .630       .360
    115.0    111.0     .560       .700
    114.0    269.0     1.02       .500
    114.0    269.0     1.020      .710
    431.0    137.00    .6700      1.E31
```

*** NOTE *** The variables appearing in both input files are combined into one variable (Easting and Northing), and these variables took on the values from the first file.

## Report

Upon selection of this option the Report menu is displayed. The Report menu provides the options necessary to generate a listing of specified variables in "Report" form. The "Report" listing is described in the Execute option. The menu line appears as follows:

```
Files  Variables  Execute  Quit
```

**Files** - This option is used to specify two file names, the input and output files. After the file names have been entered, you are prompted for the sequence option from the toggle field. If "on" is selected for the sequence option, then the observation (row) number is indicated on the "Report" listing.

**Variables** - This option is used to specify those variables that are to be included in the "Report" listing. You are prompted for a variable to be selected from a toggle field. A yes/no prompt provides an opportunity to select another variable. Indicating no causes control to be returned to the Report menu. The list of variables are displayed on the screen after each selection.

**Execute** - The "Report" listing will be generated upon selection of this option. This listing is then stored in the specified output file. When this operation is complete a message appears indicating that the data have been sent to the output file. Upon pressing any key, control is returned to the Report menu. The following is a description of the "Report" listing.

The "Report" listing can be generated with or without the sequence option enabled. If the sequence option is enabled then each data record will be preceded by an observation number (record number). Each page lists up to four variables with 50 data records each. If more than four variables are selected then all the data records for the first four variables are printed. The page numbering is reset to one and the next four variables are printed. An example report with the sequence option enabled follows.

Example output from the Report option:

```
                                                                  Page      1
  Demo1.dat - ficticious data set 1
            Easting         Northing           Lead          Arsenic
  Obs.         feet             feet            ppm              ppm
    1.     320.0000         311.0000       .8500000         1.000000
    2.     119.0000         119.0000       .6300000         2.000000
    3.     115.0000         111.0000       .5600000         3.000000
    .          .                .               .                .
    .          .                .               .                .
    .          .                .               .                .
```

## Sort

Upon selection of this option the Sort menu is displayed. The Sort menu provides the options necessary to sort a variable in ascending order. If a selected variable's sample has to be relocated, then the entire record associated with that sample is also moved. An example of the Sort operation is shown in the Execute option. The menu line appears as follows:

```
Files  Variable  Execute  Quit
```

**Files** - This option is used to specify two Geo-EAS file names, the first is the input file and the second is an output file.

**Variable** - This option is used to specify the variable to be sorted. You are prompted for a variable which is selected from a toggle field. After the selection, pressing any key returns control to the Sort menu.

**Execute** - Upon selection of this option, the specified variable is sorted in ascending order. When the process is complete, the data are stored in the specified output file. A message appears informing you that the data have been sent to the output file. Upon pressing any key, control is returned to the Sort menu.

As an example the following output file, Out4.dat, was generated when the variable Easting of the input file, Demo1.dat, was sorted.

Out4.dat

```
Demo1.dat - ficticious data set 1
    3
Easting   feet
Northing  feet
Arsenic   ppm
     114.0         269.0         1.02
     114.0         269.0         1.02
     115.0         111.0         .560
     119.0         119.0         .630
     320.0         311.0         .850
     431.0         137.0         .670
```

The variable Easting appears in ascending order. Note that not only have the values of the variable Easting been relocated, but all values (the line) associated with Easting has been moved.

# SECTION 6

# TRANS

## 6.1 WHAT TRANS DOES

Trans was designed to create, delete, or modify Geo-EAS data file variables. Refer to the section on Geo-EAS data files for more information on input data. The operations may be unary (one operand, one operator), binary (two operands, one operator), or a indicator transform operation, described below. An operand may be either a variable or a constant. The operator maybe an operation, such as addition or finding the square root. The results generated by the specified operation may replace the contents of an existing variable or a new variable may be created. The variable specified to accept the results is called the result variable. Missing values may be generated in two circumstances: when an operand is a missing value, or when an operation is undefined (as in division by zero).

Trans uses a temporary file called a Scratch File to store the data read from a Geo-EAS data file. The temporary file is called ZZSCTCH1.FIL. The Read option in the Main menu (described below) reads the Geo-EAS data file and stores the data in the temporary file. Each time an operation is performed, the required data are retrieved from the temporary file and the newly generated data are stored in the temporary file. A list of variable names is displayed on the screen to indicate which variables reside in the scratch file. If a variable is deleted using the Delete option from the Main menu, then that data are deleted from the temporary file. The variable name is also deleted from the screen. The Save option from the Main menu is used to move the data from the temporary file to the specified Geo-EAS output data file.

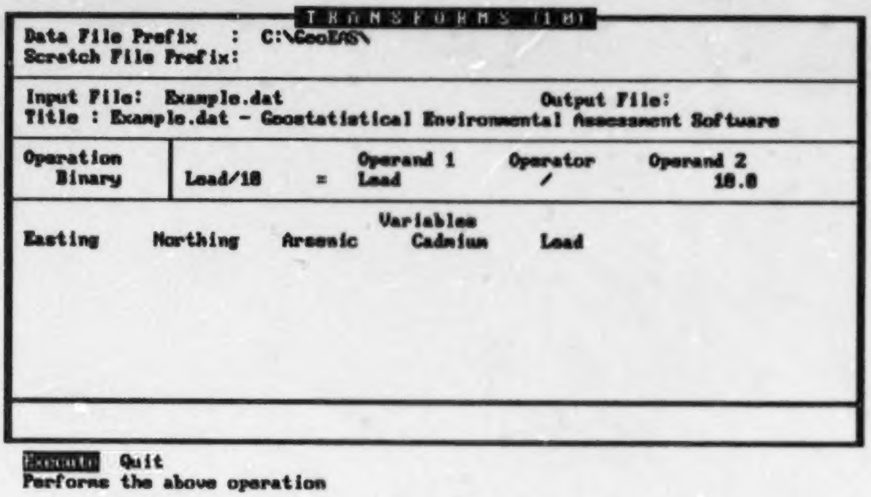
## 6.2 DATA LIMITS

Trans reads as well as generates Geo-EAS data files containing a maximum of 48 variables and 10,000 samples. If a file should contain more than 10,000 samples then only the first 10,000 samples are read and a warning message is displayed. If an attempt is made to create a 49th variable then an error message is displayed.

## 6.3 THE MENU HIERARCHY

```
Trans --Prefix
       |
       |Read
       |
       |Title
       |
       |Create -- New Variable ---- Unary Operation     ->
       |        |               | |
       |        | Old Variable -/ | Binary Operation    ->
       |        |                 |
       |        |                 | Indicator Transform ->
       |        |                 |
       |        |                 \ Quit
       |        |
       |        \ Quit
       |
       | Delete
       |
       | Save
       |
       \ Quit

-> Unary Operation ------ Operation -- Constant ---- Execute
                        |            |           | |
                        |            | Variable -/ \ Quit
                        |            |
                        |            \ Quit
                        |
                        \ Quit

-> Binary Operation ----- Constant ---- Operation -- Constant ---- Execute
                        |           | |            |           | |
                        | Variable -/ |            | Variable -/ \ Quit
                        |             |            |
                        |             |            \ Quit
                        |             |
                        |             \ Quit
                        |
                        \ Quit

-> Indicator Transform -- Variable - Cutoff
                        |
                        | Execute
                        |
                        \ Quit
```

## 6.4 THE MAIN MENU



```
                          TRANSFORMS (1.0)
Data File Prefix   :  C:\GeoEAS\
Scratch File Prefix:

Input File:  Example.dat                          Output File:
Title : Example.dat - Geostatistical Environmental Assessment Software

Operation  |                 Operand 1     Operator      Operand 2
  Binary   | Load/10    =    Load             /               10.0

                             Variables
Easting     Northing    Arsenic     Cadmium     Load


Execute  Quit
Performs the above operation
```

Figure 6-1 Trans Main Screen

The Main screen and menu (Figure 6-1) provide the options necessary to read and save Geo-EAS data files and to create, delete, or modify variables. The menu line appears as follows:

```
Prefix  Read  Title  Create  Delete  Save  Quit
```

**Prefix**

The Prefix option is used to enter the prefix for the data file and scratch file.

**Data**

The Data option is used to enter the name of a Geo-EAS data file.

**Title**

The Title option is used to specify a descriptive title for the output Geo-EAS data file. The title can be up to 66 alphanumeric characters. No error checking is performed.

**Create**

The Create option provides access to the Create menu. The Create menu (described below) is the first in a series of menus that provide options used to specify a new or existing variable as the result variable and to perform a specified operation (unary, binary, transform indicator).

**Delete**

The Delete option is used to select an existing variable that is to be deleted. The variable is selected from a toggle field. Upon making the selection the message "Do you really want to delete this variable?...(Y/N)" is displayed. If <Y> is pressed the variable is deleted from the temporary file and from the list of variable names on the screen. Subsequent to entering your choice, control is returned to the Main menu.

**Save**

When the Save option is selected, the data stored in the temporary file are written to a specified data file. A prompt is issued for the output Geo-EAS data file name. If blanks are entered then an error message is displayed. If the output file already exists then a Yes/No prompt will appear asking if the file should be overwritten. The data in the temporary file is copied to the output Geo-EAS data file. If an error should occur while opening the output file then an error message is displayed. While the file is being saved the message "Writing data..." appears. After the data has successfully been written a message is displayed (press any key to continue).

## 6.5 THE CREATE MENU

The Create menu provides the options necessary to perform transformations to a Geo-EAS data file. The menu line appears as follows:

```
New Variable  Old Variable  Quit
```

**New Variable**

When the New Variable option is selected a new variable is created in the scratch file. The new variable takes on values generated from the specified operation (unary, binary, indicator transform). You are prompted for the new variable name. If the given variable name is blank then a message to this effect appears (pressing any key returns control to the Create menu). If the variable name already exists then a warning message appears (pressing any key passes control to the Operation menu). If the variable name is unique to the scratch file then you are prompted for a description of the measurements. The field for the measurements description can accept up to 10 alphanumeric characters. After entering the measurements description, control is passed to the Operation menu (described below).

**Old Variable**

This option is used to specify an existing variable whose contents are replaced by the results of the specified operation (unary, binary, indicator transform). You are prompted for a variable from the toggle field. After making the selection, you are asked if you wish to change the variable's current name or measurements description. When indicating yes, you may retain or change the name by entering up to 10 alphanumeric characters into the field. If blanks are entered then an error message is displayed (you are then returned to the alphanumeric field and prompted for another variable name). If the given variable name is the same as the existing variable, then a message appears and you are prompted for a new variable name. You are then prompted for a measurements description. The measurements description of the old variable is displayed by default. You may retain or enter another description. Pressing <enter> causes the Operation menu (described below) to be activated.

## 6.6 THE OPERATION MENU

The Operation menu provides a selection of transformation operations. The menu line appears as follows:

```
Unary Operation  Binary Operation  Indicator Transform  Quit
```

### Unary Operation

This option provides access to the Unary Operation menu. The Unary Operation menu (described below) is the first of three menus that provides options needed to complete a unary operation. After a selection is made from one menu, control is passed to the succeeding menu. The Unary Operation menu provides a selection of unary operators. Next, the Unary Operand menu provides the choice of a constant or an existing variable for the operand. Finally, the Execute menu provides the Execute option.

The unary operations perform an operation on one operand. The operations are shown below as they would appear in the toggle field:

**sqrt** - Computes the square root of an operand.
**log** - Computes the base 10 logarithm of an operand.
**ln** - Computes the natural logarithm of an operand.
**truncate** - Truncates the operand.
**exp** - Computes e to the power of x (exp) where e is 2.71828... and x is the operand. Note that a numeric overflow can result in using the exp operation. In such a case the program will abnormally terminate (crash).
**rank** - Determines the rank of an existing variable. This operation assigns an integer value to the result variable based upon the rank of a specified existing variable in a sorted list.

The Unary Operation menu provides an option to select a unary operation. The menu line appears as follows:

```
Operations  Quit
```

**Operation** - This option is used to specify the unary operator. You are prompted for a unary operator from the toggle field. Upon making the selection, control is passed to the Unary operand menu (described below).

The Unary Operand menu provides the option to select an operand for the unary operation. The menu line appears as follows:

```
Constant  Variable  Quit
```

**Constant** - This option is used to assign a constant value to the unary operand. You are are prompted for the constant value. The constant value is entered into a numeric(floating point) field. The default value is initially zero. If the value entered results in a numeric overflow then a message is displayed. Upon pressing any key, control is returned to the Unary Operand menu. If the constant value entered is acceptable then control is passed to the Execute menu (described below).

**Variable** - This option is used to select an existing variable for use as the unary operand from a toggle field. Upon making the selection, control is passed to the Execute menu (described below).

The Execute menu provides the option necessary to initiate any unary operation. The menu line appears as follows:

```
Execute  Quit
```

**Execute** - This option is used to initiate the unary operation. During processing the message "Processing data..." is displayed on the screen. After processing is complete the minimum and maximum values of the variable will be displayed on the message line. After pressing any key, you are asked for the number of significant digits for the output format. The range of digits is 1 through 12 inclusive. A FORTRAN format (which is the output format) is constructed based on the expression Gx + 7.x where x is the digit entered by you, ie., significant digits. For example, if 7 is entered then G14.7 is the output format. For more information on the FORTRAN formats refer to a FORTRAN reference manual. If the digit for x is outside the acceptable range then 9 will be used by default. If the given format is not appropriate for writing the variable to the output file then a message is displayed and you are prompted for a new digit for x. You can best select x by determining (using the minimum and maximum values displayed on the message line) the maximum number of digits to the left of the decimal point. Then decide the maximum number of digits to the right of the decimal point. The sum of the two values is x. Increase the sum by one if the value is negative. If any missing values are generated then the number of missing values and the name of the variable are displayed on the screen. After processing is complete, control is returned to the Main menu. If an operand is a constant and contains a missing value then the result of that operation will be a missing value. If the operand is a variable as opposed to a constant, and a sample from that variable results in an undefined operation, then a missing value is generated. Whenever an error message is displayed, processing is halted and control is returned to the Operation menu. As noted previously, the operation (exp) may result in a numeric overflow causing the program to abnormally terminate (crash).

**Binary Operation**

This option provides access to the Binary Operation menu. The Binary Operation menu is the first of four menus that provides options needed to complete a binary operation. After a selection is made from one menu, control is passed to the succeeding menu. First, the Binary Operand One menu (described below) provides a selection of a constant or an existing variable for operand one. Second, the Binary Operation menu provides a selection of binary operators. Next, the Binary Operand Two menu is similar to the Binary Operand One menu with the exception that the selection is for operand two. Finally, the Execute menu provides the Execute option.

The binary operations perform an operation requiring two operands. The operations are shown below as they would appear in the toggle field:

+ - Addition
/ - Division of the first operand by the second operand.
x - Multiplication
- - Subtraction
** - Exponentiation which raises the first operand to the power of the second operand.

The Binary Operand One menu provides the options to select operandl for the binary operation. The menu line appears as follows:

```
Constant  Variable  Quit
```

**Constant** - This option is used to assign a constant value to the binary operand one. This option is similar to the constant option noted in the Unary Operand menu section (described earlier). The exceptions are that the wording in the messages refers to the binary operand one and not the unary operand, and upon entering a valid constant value, control is passed to the Binary Operation menu (described below). If the constant value is unacceptable then control is returned to the Binary Operand one menu.

**Variable** - This option is used to assign an existing variable to the binary operand one. This option is similar to the variable option noted in the Unary Operand menu section (described earlier). The exceptions are that the wording refers to binary operand one and not the unary operand, and upon making the selection, control is passed to the Binary Operation menu (described below).

The Binary Operation menu provides the option to select a binary operator. The menu line appears as follows:

```
Operations  Quit
```

**Operation** - This option is used to specify the binary operator. You are prompted for a binary operator from a toggle field. Upon making the selection control is passed to the Binary Operand Two menu (described below).

The Binary Operand Two menu provides the options to select operand2 for the binary operation. The menu line appears as follows:

```
Constant  Variable  Quit
```

**Constant** - This option is used to specify a constant for the binary operand two. This option is similar to the binary operand one constant option described previously in the Binary Operand One menu. The exceptions are that the wording refers to operand two and not operand one, and upon entering an acceptable value, control is passed to the Execute menu (described below).

**Variable** - This option is used to specify an existing variable for binary operand two. It is similar to the binary operand one variable option described previously in the Binary Operand One menu. The exceptions are that the wording refers to operand two and not operand one, and upon making a selection, control is passed to the Execute menu (described below).

The Execute menu provides the option needed to initiate the binary operation. The menu line appears as follows:

```
Execute  Quit
```

**Execute** - This option initiates the binary operation. During processing the message "Processing data..." is displayed on the screen. The Execute(binary) option causes the same prompts as in the Execute option of the unary operation. Refer to the Execute option of the Execute menu discussed previously in the Unary operation section. As noted previously, the operation exponentiation may result in a numeric overflow causing the program to abnormally terminate(crash).

### Indicator Transform

The indicator transform is an operation requiring two operands. The first operand is an existing variable and the second operand is a constant called the threshold value. The result variable takes on the value 1.0 if the input variable is greater than or equal to the threshold value. The result variable takes on the value 0.0 if the input variable operand is less than the threshold value. The Indicator Transform option provides access to the Indicator Transform menu.

The Indicator Transform menu provides the options to select the operands and to execute the operation. The menu line appears as follows:

```
Variable  Execute  Quit
```

**Variable** - This option is used to specify two operands. The first operand is an existing variable and the second operand is the threshold value which is a constant. The message "Select variable for operation (use <space> bar)" prompts for the variable. After selection and pressing <enter> the message "Enter constant value for threshold value" is displayed. If the constant entered causes numeric overflow then an error message is displayed.

**Execute** - This option is used to initiate the indicator transform operation. During processing the message "Processing data..." is displayed. If after processing any missing values were generated then the number of missing values and the variable name are displayed on the message line. After processing is complete the message "Processing is complete...(press any key)" is displayed. Upon pressing any key control is returned to the Main menu.

# SECTION 7

# STAT1

## 7.1 WHAT STAT1 DOES

Stat1 is an interactive program which computes basic univariate statistics and displays histograms or probability plots for variables in a Geo-EAS data set. Options are available for calculating statistics on the natural log of the selected variable, for specifying a variable to be used as a "weighting factor", and for performing calculations on subsets of the input data through the use of upper and lower limits. A "Batch Statistics" option has been included which will produce a report of statistics for all variables in the specified data file.

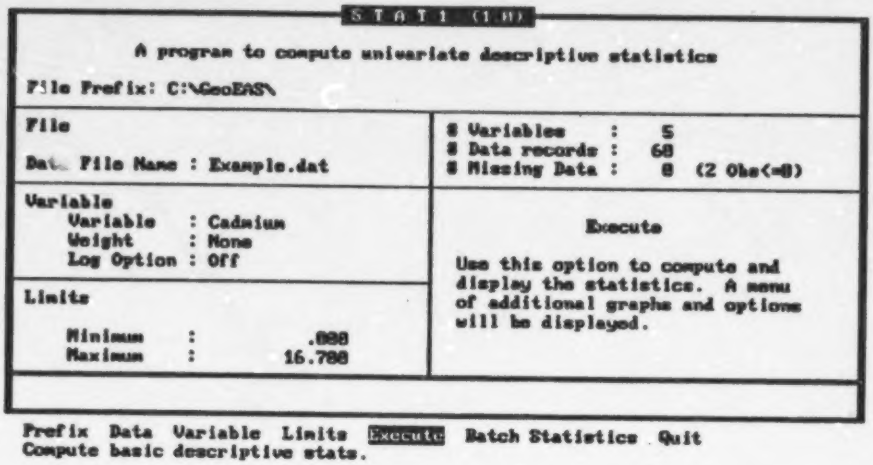
## 7.2 DATA LIMITS

Stat1 requires that the maximum number of variables in the input data file not exceed 48. The data file may contain up to 10,000 samples. If the data file contains more than 10,000 samples, then only 10,000 will be used by Stat1.

## 7.3 THE MENU HIERARCHY

```
Stat1 -- Prefix
        | Data
        | Variable
        | Limits
        | Execute ----------- Histogram ---- Type
        |                   |              | Class Limits
        |                   |              | Axes
        |                   |              | Titles
        |                   |              | Results
        |                   |              | View Graph
        |                   |              \ Quit
        |                   | Probability
        |                   | Examine
        |                   \ Quit
        | Batch Statistics
        \ Quit
```

## 7.4 THE MAIN MENU



```
                              STAT1 (1.0)
        A program to compute univariate descriptive statistics

File Prefix: C:\GeoEAS\

File                                 # Variables    :    5
                                     # Data records :   60
Data File Name : Example.dat         # Missing Data :    0  (2 Obs<=0)

Variable
     Variable   : Cadmium                     Execute
     Weight     : None
     Log Option : Off                Use this option to compute and
                                     display the statistics.  A menu
Limits                               of additional graphs and options
                                     will be displayed.
     Minimum    :           .000
     Maximum    :         16.700

Prefix  Data  Variable  Limits  Execute  Batch Statistics  Quit
Compute basic descriptive stats.
```

Figure 7-1 Stat1 Main Screen

The main menu and screen (Figure 7-1) has options to allow specification of the data file names, the selection of the variable to be used, the selection of upper and lower limits for the variable, calculation of statistics (univariate), and generation of a batch statistics report. The menu line appears as follows:

```
Prefix  Data  Variable  Limits  Execute  Batch Statistics  Quit
```

**Prefix**

The prefix option is used to enter the prefix for the data file name.

**Data**

The Data option is used to enter the name of a Geo-EAS data file.

**Variable**

The variable option allows the selection of a variable for which univariate statistics are to be generated. The "weighting factor" variable can be selected at this time. The choices available for variables are the variable names specified in the data file. The natural log transform may be chosen to compute log statistics. Both the weight and log parameters may be used simultaneously. The screen fields accessed from this option are:

Variable - A toggle field for selecting the variable name whose values are to be used to compute the univariate statistics. The default value is the first variable in the data set.

Weight - A toggle field for selecting an optional variable name whose values are to be used as the weighting factor. If the weighting factor variable is chosen, then the resulting univariate statistics are "weighted" (the statistics are calculated for Weight value multiplied by Variable value). The default weighting factor variable is "None"(in which case the weighting factor is 1).

Log Option - A two valued toggle (On/Off) field to enable or disable the Log option. If the Log option is enabled and a weighting factor variable selected then the statistics are calculated for the Weight value multiplied by the (natural log of the Variable value). Whenever the Log option is enabled sample values less than or equal to zero are counted but not used in the computation. The default value is "Off".

**Limits**

The Limits option allows computation of statistics for a subset of the data which lie between the specified minimum and maximum sample values. You may specify the upper and lower limits placed on the values used for computing the basic statistics.

Minimum - A numeric field which contains the lower limit on the sample values used in the computation. The default value is the minimum value of the selected variable.

Maximum - A numeric field which contains the upper limit on the sample values used in the computation. The default value is the maximum value of the selected variable.

**Execute**

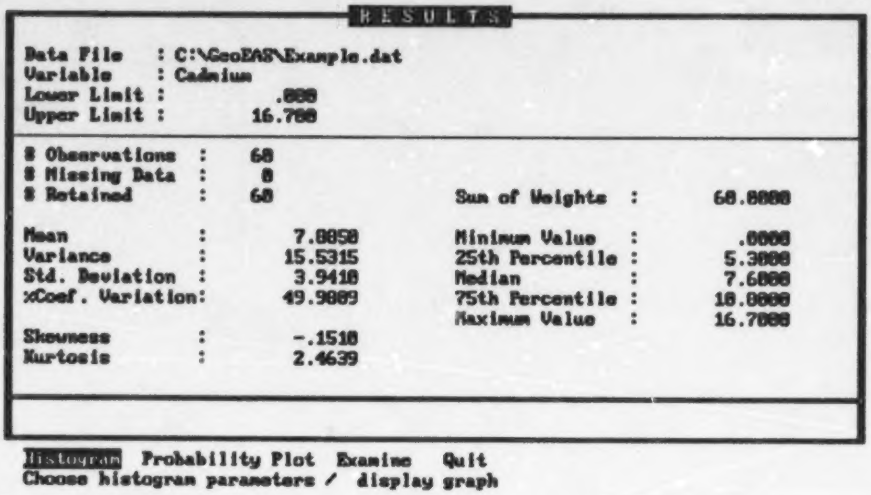
The Execute option provides access to the Results screen and menu. When the Log option is enabled the number of samples less than or equal to zero is displayed. If this occurs, pressing any key provides access to the Results screen. See the section on the Results menu below for more information.

**Batch Statistics**

The Batch Statistics option allows generation of a report of univariate statistics for all variables in the data set with no need for interaction. The statistics can be saved to a file or printed. A two valued toggle field ("printer" or "file") is used to make this selection and appears on the message line. If the selection is "printer" then the printer must be on and "online". If "file" is selected then you are prompted for a file name. The field accepts up to 14 alphanumeric characters. If the file exists then a yes/no prompt asks if you wish to overwrite. Indicating no will return you to the menu. If the field is blank then an error message is displayed. In such a case pressing any key returns you to the Main menu.

*** NOTE *** the file by produced by the Batch Statistics option is not a Geo-EAS data file.

## 7.5 THE RESULTS MENU



```
                               RESULTS

Data File    : C:\GeoEAS\Example.dat
Variable     : Cadmium
Lower Limit :            .000
Upper Limit :          16.700

# Observations  :    60
# Missing Data  :     0
# Retained      :    60              Sum of Weights   :      60.0000

Mean            :          7.0050    Minimum Value    :        .0000
Variance        :         15.5315    25th Percentile  :       5.3000
Std. Deviation  :          3.9410    Median           :       7.6000
%Coef. Variation:         49.9809    75th Percentile  :      10.0000
                                     Maximum Value    :      16.7000
Skewness        :          -.1510
Kurtosis        :          2.4639

Histogram  Probability Plot  Examine   Quit
Choose histogram parameters /  display graph
```

Figure 7-2 Stat1 Results Screen

The Results screen and menu provides options to display a probability plot (described below), to display a ranked listing of data values and order statistics (shown below as "Examine Data"), and to display the Histogram screen and menu. The Results Screen displays univariate statistics for the selected variable. The menu line appears as follows:

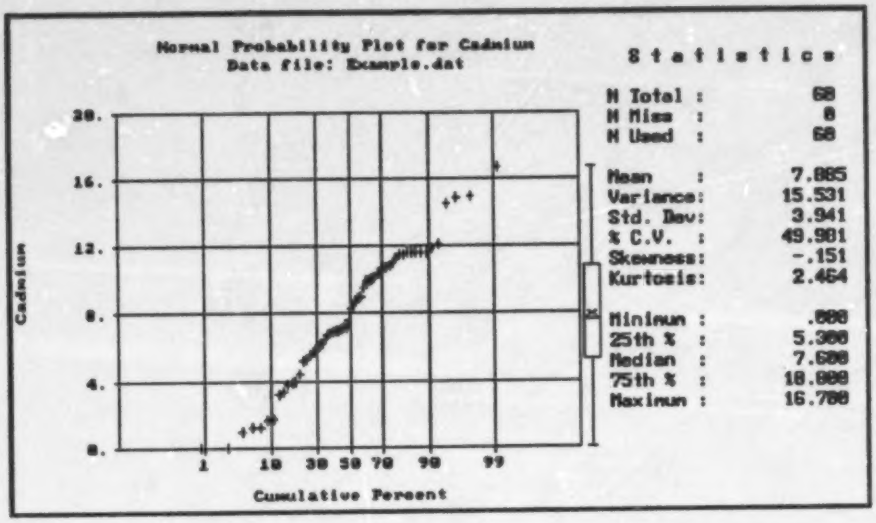
```
Histogram  Probability Plot  Examine  Quit
```

### Histogram

The Histogram option provides access to the Histogram screen and menu. First a default histogram is displayed. See the section on the Histogram menu below for more information.

### Probability Plot

When the Probability Plot option is selected a probability plot (Figure 7-3) is computed and displayed on the screen. The plot is a graph of the ranked variable values, plotted against their cumulative percentiles. The vertical axis is scaled in units of the variable and the horizontal axis is scaled in units of cumulative percent. A boxplot appears at the right side of the plot area along with univariate statistics, the quartiles, and the minimum and maximum values.



```
S t a t i s t i c s

N Total :        60
N Miss  :         0
N Used  :        60

Mean    :     7.885
Variance:    15.531
Std. Dev:     3.941
% C.V.  :    49.981
Skewness:     -.151
Kurtosis:     2.464

Minimum :      .000
25th %  :     5.300
Median  :     7.600
75th %  :    10.000
Maximum :    16.700
```

Figure 7-3 Statl Probability Plot

The boxplot (Figure 7-4) is a graph which depicts the limits, quartiles, median, and mean of a set of values. Boxplots are used in the Probability Plot and Histogram displays. A Boxplot is comprised of a rectangle containing an "X" and a dividing line. A line extends outward from each end of the rectangle. The rectangle represents the interquartile range (the range of values between the 1st and 3rd quartiles). The dividing line marks the position of the median in the interquartile range, and the "X" marks the arithmetic mean. The endpoints of the outward extending lines depict the minimum and the maximum values.

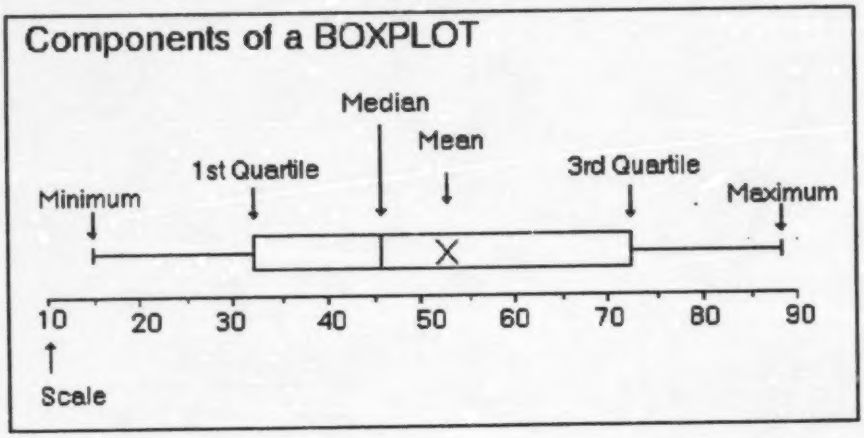
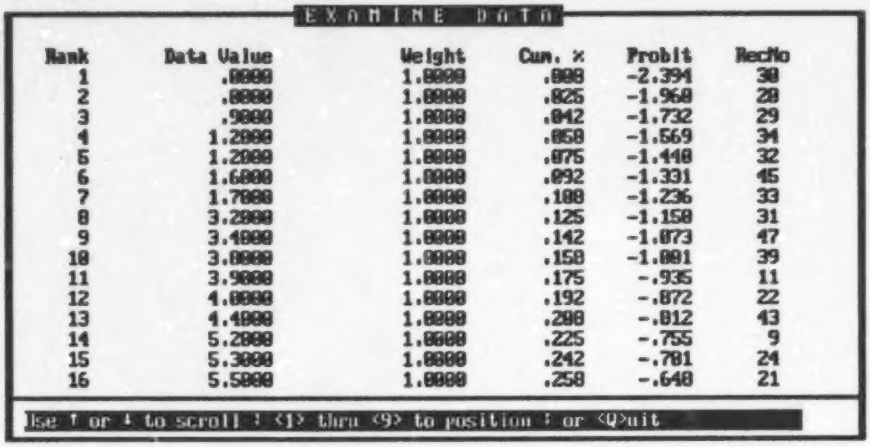

Components of a BOXPLOT
Median
Mean
1st Quartile
3rd Quartile
Minimum
Maximum
X
10
20
30
40
50
60
70
80
90
Scale

Figure 7-4 The Components of a Boxplot

**Examine**

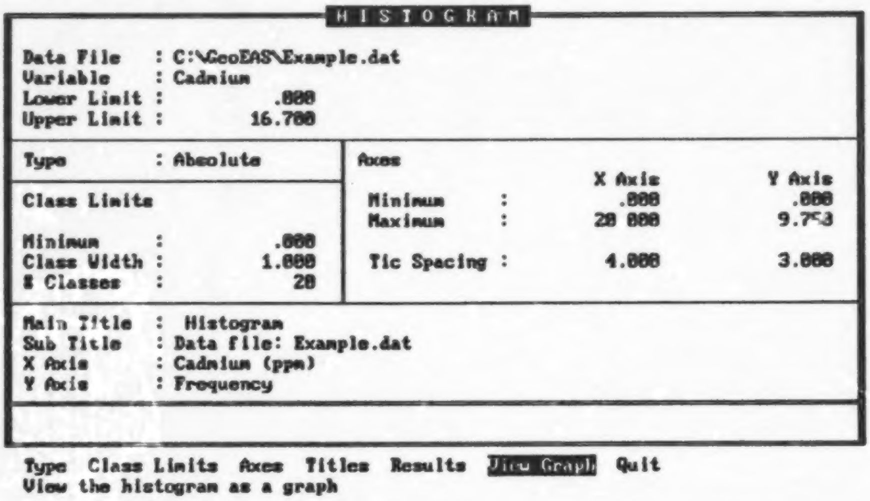
The Examine option allows access to a screen that displays a ranked listing of data values and order statistics. An example of this screen is displayed in Figure 7-5. The RecNo column indicates the samples sequence in the data file. The <up>, <down>, <pg up>, <pg dn>, <home>, and <end> keys may be used to scroll the display to the desired position. Pressing <q> will cause the Results screen and menu to appear.



```
Rank      Data Value            Weight    Cum. %    Probit    RecNo
   1           .0000            1.0000      .008    -2.394       30
   2           .0000            1.0000      .025    -1.960       20
   3           .9000            1.0000      .042    -1.732       29
   4          1.2000            1.0000      .058    -1.569       34
   5          1.2000            1.0000      .075    -1.440       32
   6          1.6000            1.0000      .092    -1.331       45
   7          1.7000            1.0000      .108    -1.236       33
   8          3.2000            1.0000      .125    -1.150       31
   9          3.4000            1.0000      .142    -1.073       47
  10          3.8000            1.0000      .158    -1.001       39
  11          3.9000            1.0000      .175     -.935       11
  12          4.0000            1.0000      .192     -.872       22
  13          4.4000            1.0000      .208     -.812       43
  14          5.2000            1.0000      .225     -.755        9
  15          5.3000            1.0000      .242     -.701       24
  16          5.5000            1.0000      .258     -.640       21

Use ↑ or ↓ to scroll | <1> thru <9> to position | or <Q>uit
```

Figure 7-5 Stat1 Examine Screen

## 7.6 THE HISTOGRAM OPTIONS MENU



```
Data File    : C:\GeoEAS\Example.dat
Variable     : Cadmium
Lower Limit  :          .000
Upper Limit  :        16.700

Type         : Absolute          Axes
                                                     X Axis        Y Axis
Class Limits                      Minimum      :       .000          .000
                                  Maximum      :     20.000         9.753
Minimum      :          .000
Class Width  :         1.000      Tic Spacing  :      4.000         3.000
# Classes    :            20

Main Title   :  Histogram
Sub Title    : Data file: Example.dat
X Axis       : Cadmium (ppm)
Y Axis       : Frequency

Type  Class Limits  Axes  Titles  Results  View Graph  Quit
View the histogram as a graph
```

Figure 7-6 Stat1 Histogram Options Screen

options necessary to generate a histogram (frequency distribution plot) of the data. You can examine the histogram results or view the graph. A histogram is displayed before the Histogram menu is accessed. Pressing any key will access the Histogram menu from the histogram display. The histogram plot is discussed below in the View Graph option of the Histogram menu. The menu line appears as follows:

```
Type  Class Limits  Axes  Titles  Results  View Graph  Quit
```

### Type

The Type option is used to select the Frequency type. The Frequency type is selected from a two valued toggle field containing the choices "Absolute" and "Relative". The choice "Absolute" will generate a traditional histogram; "Relative" will cause the frequencies to be displayed as a percentage of the total number of samples (or weight of the samples) retained.

### Class Limits

The Class Limits option allows the specification of the class upper and lower limits. You will be prompted for the minimum value, the class width, and the number of classes. The upper limit of the first class is the sum of the minimum value and the class width. The upper limit for all classes is the sum of the minimum value and (class width multiplied by the number of classes). The screen fields accessed from this option are:

Minimum - A numeric field whose default value is the minimum value which was specified in the Limits option of the Main menu discussed earlier.

Class Width - A numeric field whose default value is calculated. This value must be greater than zero. If it is not then an error message appears and you are prompted for a new value.

# Classes - A numeric field for which the value entered must be in the range of 1 to 100. If the entry is erroneous then an error message appears and the default value is set to 100.

### Axes

The Axes option allows the specification of the coordinate limits for the horizontal (X) and vertical (Y) axes. Tic spacing for the X and Y axes is also specified at this time. The screen fields accessed from this option are:

Minimum - Two numeric fields used for entering the minimum coordinate values to be used on the X and Y axes. The default value for X is determined from the data file for the variable for which univariate statistics are computed and from the upper and lower class limits. The default value for Y is zero.

Maximum - Two numeric fields used for entering the maximum coordinate values to be used on the X and Y axes. If the maximum value exceeds the minimum value then an error message is displayed and the default value is the previous field entry. The default values displayed are determined from the data file for the variable for which univariate statistics are computed and from the upper and lower class limits.

Tic Spacing - Two numeric fields used for entering the tic spacing to be used on the X and Y axes. The default values displayed are determined from the data file for the variable for which univariate statistics are computed and from the upper and lower class limits.

### Titles

The Titles option allows you to enter the title and labels for the graph. The Hershy character sets of 33 fonts are used for plotting alphanumeric labels. The file HERSHY.BAR contains this information and is included with the software.

Main Title - An alphanumeric field which may contain up to 60 characters for the title on the graph. The default title is "Histogram". When a weighting factor has been selected then the title is "Weighted Histogram".

Subtitle - An alphanumeric field which may contain up to 60 characters for the subtitle of the graph. The default subtitle is "Data file: <input data file name>".

X Axis - An alphanumeric field which may contain up to 60 characters for the X axis. The default label is "<variable name> (<units description>)" where the variable name and the measurements description are taken from the variable selected for univariate statistics. If the Log option is on then "LN" precedes the variable name.

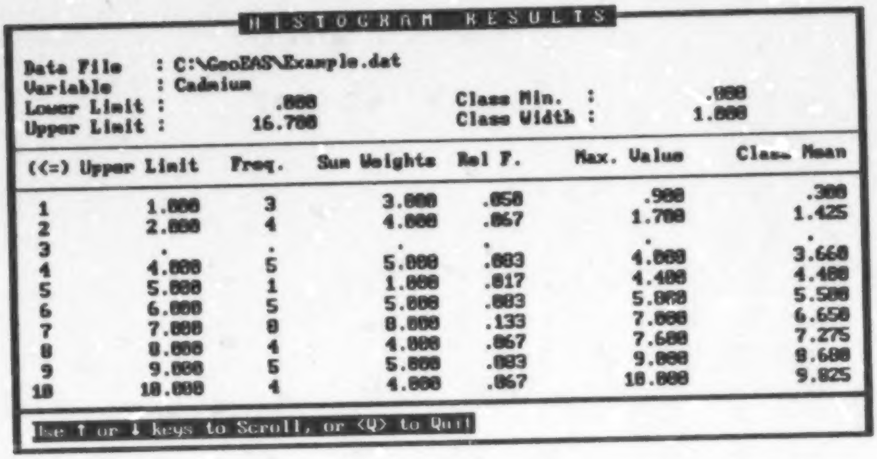
Y Axis - An alphanumeric field which may contain up to 60 characters for the Y axis. The default label is "Frequency".

### Results

The Results option allows access to the Histogram Results screen and menu (Figure 7-7). This screen displays the histogram results. The results are in tabular form. The display may be scrolled as in the Examine option (described above).

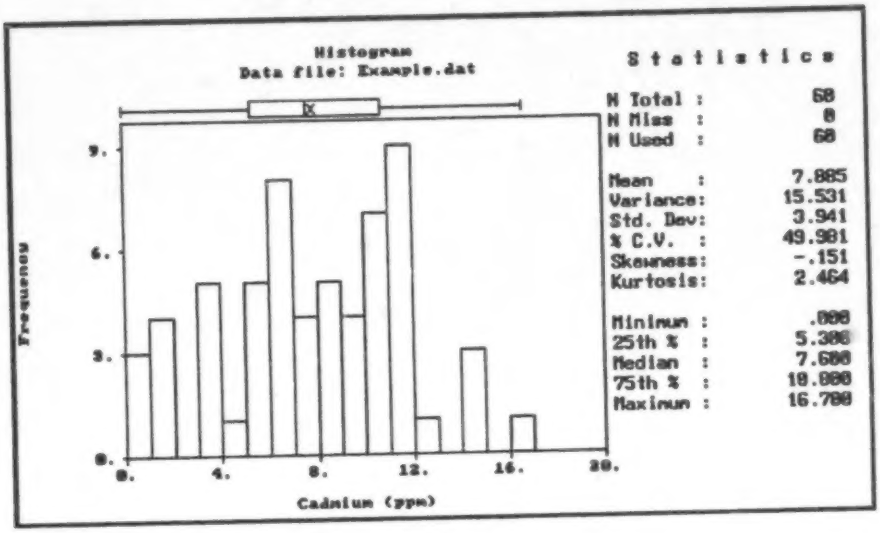
### View Graph

The View Graph option allows access to a screen that displays the histogram (Figure 7-8). The resulting histogram is accompanied by a box plot (described in the Probability Plot Option of the Results menu), and some univariate statistics.



```
                    H I S T O G R A M   R E S U L T S

Data File    : C:\GeoEAS\Example.dat
Variable     : Cadmium
Lower Limit :            .000          Class Min.  :          .000
Upper Limit :          16.700          Class Width :         1.000

((=) Upper Limit   Freq.   Sum Weights  Rel F.    Max. Value    Class Mean

 1        1.000      3          3.000    .050          .900          .300
 2        2.000      4          4.000    .067         1.700         1.425
 3          .        .            .        .             .             .
 4        4.000      5          5.000    .083         4.000         3.660
 5        5.000      1          1.000    .017         4.400         4.400
 6        6.000      5          5.000    .083         5.000         5.500
 7        7.000      8          8.000    .133         7.000         6.650
 8        8.000      4          4.000    .067         7.600         7.275
 9        9.000      5          5.000    .083         9.000         8.600
10       10.000      4          4.000    .067        10.000         9.825

Use ↑ or ↓ keys to Scroll, or <Q> to Quit
```

Figure 7-7     Stat1 Histogram Results Screen



```
  S t a t i s t i c s

N Total :          60
N Miss  :           0
N Used  :          60

Mean     :      7.885
Variance:      15.531
Std. Dev:       3.941
% C.V.  :      49.981
Skewness:       -.151
Kurtosis:       2.464

Minimum :        .000
25th %  :       5.300
Median  :       7.600
75th %  :      10.000
Maximum :      16.700
```

Figure 7-8     Stat1 Histogram

## SECTION 8

## SCATTER

### 8.1 WHAT SCATTER DOES

Scatter produces scatter plots of variable pairs in a Geo-EAS data file. Options allow for log and semi-log plots and for a regression line to be calculated. Scaling and numeric tickmark labeling for the axes, and titles are computed automatically.

### 8.2 DATA LIMITS

Scatter requires that the input data file contain at least three but not more than 48 variables. These should consist of an X and Y coordinate and a third variable which will be posted. The data file may contain up to 10000 samples. If the data file contains more than 10000 samples, only 10000 will be used by Scatter.

### 8.3 THE MENU HIERARCHY

```
Scatter --- Prefix
         |  Data
         |  Variables
         |  Options
         |  Execute
         \  Quit
```

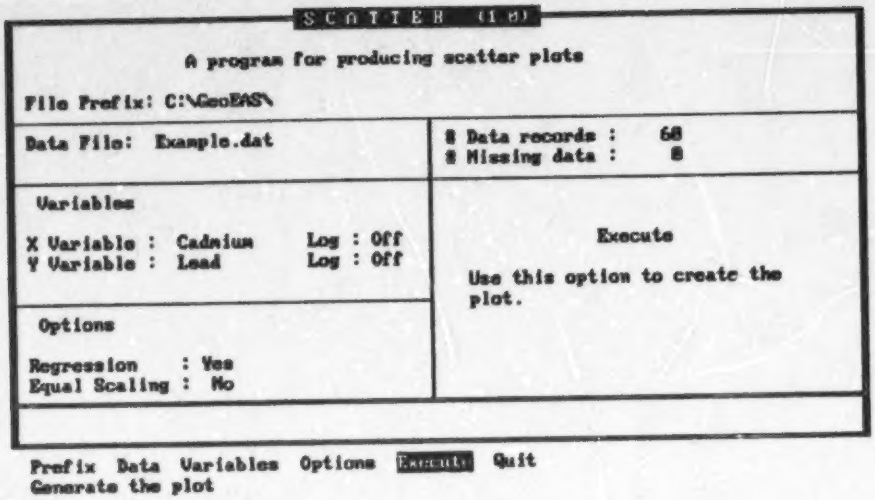
### 8.4 THE MAIN MENU

The Main menu and screen (Figure 8-1) has the options to allow specification of the data file name, the selection of the variables to be used and other program options. The menu line appears as follows:

```
Prefix  Data  Variables  Options  Execute  Quit
```

**Prefix**

The Prefix option is used to enter the prefix for file names.



```
SCATTER (1.0)

A program for producing scatter plots

File Prefix: C:\GeoEAS\

Data File:  Example.dat              # Data records :   60
                                     # Missing data :    0

Variables

X Variable :  Cadmium      Log : Off            Execute
Y Variable :  Lead         Log : Off
                                      Use this option to create the
                                      plot.
Options

Regression     : Yes
Equal Scaling :  No

Prefix  Data  Variables  Options  Execute  Quit
Generate the plot
```

Figure 8-1  Scatter Main Screen

**Data**

The Data option is used to enter the name of a Geo-Eas data file.

**Variables**

The Variables option allows the selection of variables that are to be used as the X and Y coordinate values, and the sample values to post. The choices available are the variable names as specified in the data file. The screen fields accessed from this option are:

X Variable - A toggle field for selecting the variable name whose values will be used as the X-coordinates. The default X Variable is the first variable in the data file.

Y Variable - A toggle field for selecting the variable name whose values will be used as the Y-coordinates. The default Y Variable is the second variable in the data file.

Log - Two two-valued toggle fields to enable or disable a logarithmic transformation of the X and/or Y coordinate values. The choices available are "On" (use logarithmic scaling), and "Off". If the log option is set and the number of missing data (data values less than zero, or the missing value) is equal to the number of data records, an error message is displayed. The default value is "Off"

### Options

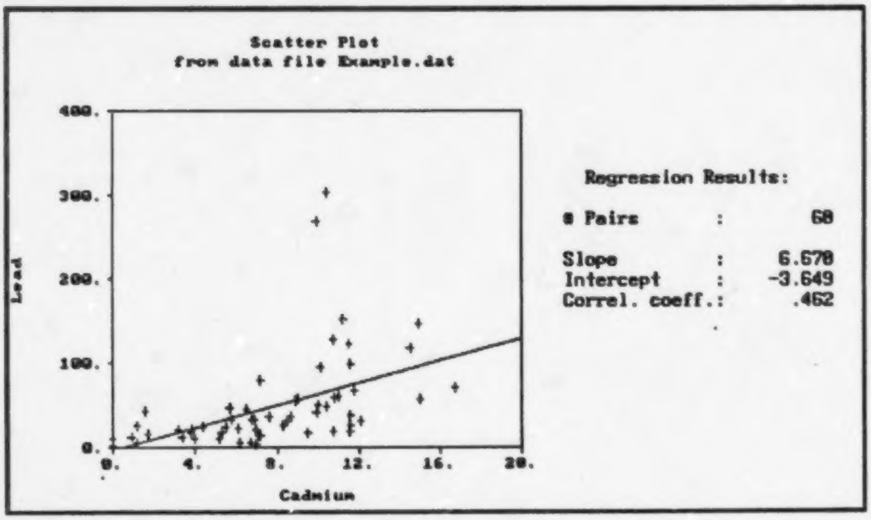
The Options option allows selection of linear regression, and a scaling option. The screen fields accessed from this option are:

Regression - A two-valued (Yes/No) toggle field to enable or disable the calculation of a regression line. The regression line and the coefficients are plotted on the graph. The coefficients are the slope and intercept of the line represented by the equation Y = Slope * X + Intercept. The Slope, Intercept and R Squared value (a measure of correlation) are displayed to the right of the graph. The default value for Regression is "Yes".

Equal Scaling - A two-valued (Yes/No) toggle field to enable or disable the use of equal scaling on the plot. If Equal Scaling is selected the true X and Y proportions are maintained on the screen. If this option is not enabled, the graph will be scaled to fill the screen. The default value is "No" (disabled).

### Execute

The Execute option is used to display the plot on the screen. After the graph has been displayed, type <q> to clear the screen and return to the Main menu. Figure 8-2 displays an example scatter plot.



```
Regression Results:

# Pairs        :      60

Slope          :   6.670
Intercept      :  -3.649
Correl. coeff.:     .462
```

Figure 8-2     Scatter Plot

## SECTION 9

## PREVAR

### 9.1 WHAT PREVAR DOES

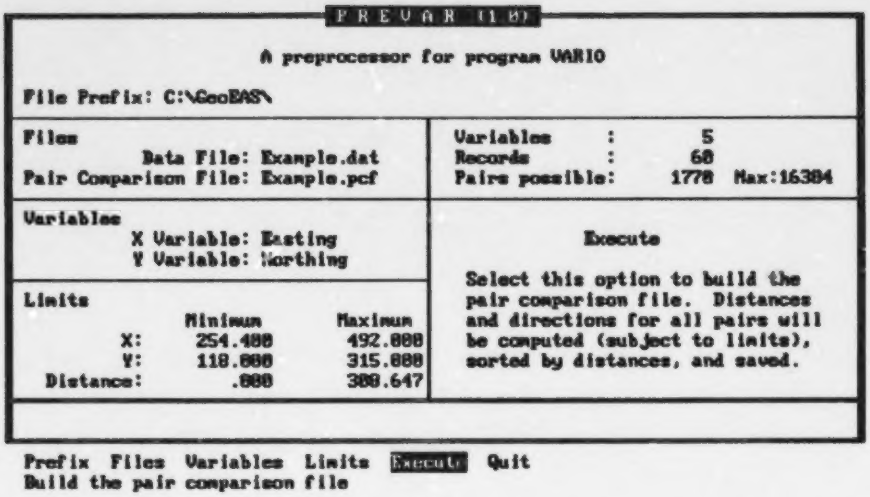
Prevar is a preprocessor program for the program Vario. All variogram calculations use the distance and relative direction between pairs of points in the sampled area. Prevar computes these so that variogram parameters may be changed and variograms recalculated more quickly in Vario. The output from Prevar is a "pair comparison file" (PCF). The pair comparison file contains the input data file contents along with distances and relative directions between pairs of sample points. This information is used by the program Vario to calculate variogram values. Limits may be imposed on the X and Y coordinate values or on the distance between points in a pair. If no limits are specified, all sample points are used for calculation. The pair comparison file can become quite large if there are many points in the data file. If is recommended that some limits on the distance between points be specified.

### 9.2 DATA LIMITS

Due to the storage requirements of Vario, Prevar must impose limits on the number of sample points in the input file and on the number of pairs for which distances and directions are computed. The input data file may contain up to 1000 samples and 48 variables. If more than 48 variables exist the data file may not be used. If more than 1000 samples exist only the first 1000 will be used. If there are N sample points in an input data file and no limits were imposed $(N^2+N)/2$ inter-pair distances and directions would be computed. A file with several hundred samples would easily generate too many pairs for Vario. The Limits option is used to restrict the number of pairs computed. Prevar will compute a maximum of 16384 pairs.

### 9.3 THE MENU HIERARCHY

```
Prevar --- Prefix
         | Files
         | Variables
         | Limits
         | Execute
         \ Quit
```



```
                              PREVAR (1.0)

                    A preprocessor for program VARIO

File Prefix: C:\GeoEAS\

Files                                     Variables      :       5
          Data File: Example.dat          Records        :      60
Pair Comparison File: Example.pcf         Pairs possible:     1770  Max:16384

Variables
         X Variable: Easting                          Execute
         Y Variable: Northing
                                          Select this option to build the
Limits                                    pair comparison file.  Distances
                 Minimum        Maximum   and directions for all pairs will
         X:      254.400        492.000   be computed (subject to limits),
         Y:      118.000        315.000   sorted by distances, and saved.
  Distance:         .000        308.647

Prefix  Files  Variables  Limits  Execute  Quit
Build the pair comparison file
```

Figure 9-1     Prevar Main Screen

The Main screen and (Figure 9-1) menu has the options to allow specification of the input data and the pair comparison file names, the selection of the variables to be used and the limits on sample coordinates and the interpair distances. The menu line appears as follows:

```
Prefix  Files  Variables  Limits  Execute  Quit
```

**Prefix**

The Prefix option is used to enter the prefix for file names.

**Files**

The Files option is used to enter the input data and the pair comparison file names. The screen fields accessed from this option are:

Data File - An alphanumeric field that may be up to 14 characters used for entering the name of a Geo-EAS data file.

Pair Comparison File - An alphanumeric field that may be up to 14 characters used to specify the name of the pair comparison file. This file will contain the contents of the input data file, and the information for each pair of samples, the distance between the two sample points and their relative direction. The default Pair Comparison File is the name of the data file with a .pcf extension. For example if the Data File is "Example.dat", the default Pair Comparison File would be "Example.pcf". If the file already exists a Yes/No prompt provides alternatives to continue or quit from the option.

**Variable**

The Variable option allows the selection of the variables that are to be used for the X and Y coordinate values. The choices are determined by the variable names in the input data file. The screen fields accessed from this option are:

X Variable - A toggle field used for selecting the variable name whose values will be used as the X coordinates. The default X variable is the first variable in the data file.

Y Variable - A toggle field used for selecting the variable name whose values will be used as the Y coordinates. The default Y variable is the second variable in the data file.

**Limits**

The Limits option is used to restrict the area and interpair distance for pairs retained in the pair comparison file. The screen field accessed from this option are:

Minimum - Three numeric fields for entering the minimum X and Y coordinate values and the minimum distance between pairs. The default values displayed are determined from the coordinate variables in the data file.

Maximum - Three numeric fields for entering the maximum X and Y coordinate values and the maximum distance between pairs. The default values displayed are determined from the coordinate variables in the data file.

**Execute**

The Execute option is used to initiate computation of pair comparison data and the creation of the pair comparison file. Distances and pair directions for all pairs in the data file are computed (subject to the limits criteria), sorted by distance, and saved in the pair comparison file. If the limit of 16384 pairs is reached, a Yes/No prompt will allow an opportunity to quit or proceed. If this occurs (and you choose to proceed) 16384 pairs will be written to the file, but it probable that other important contributing pairs will not be included. The better approach would be to <q>uit and to select an interpair distance limit or coordinate limits to restrict the number of pairs computed.

# SECTION 10

# VARIO

## 10.1 WHAT VARIO DOES

Vario is a two-dimensional variogram analysis and modeling program. Vario uses a pair comparison file (PCF) produced by Prevar to calculate variogram values and other statistics for a specified set of pair distance intervals (lags). Tolerances may be specified for pair direction and lag distance intervals. Plots of variogram values vs. distance may be displayed. Several graphs of the individual lag results may also be viewed, such as lag-histograms, box plots, postplots and lag-scatter plots. Variograms may be fitted with a model of up to 4 nested (additive) variogram structures. Lag results for individual lags may be saved in a Geo-EAS data file for analysis.

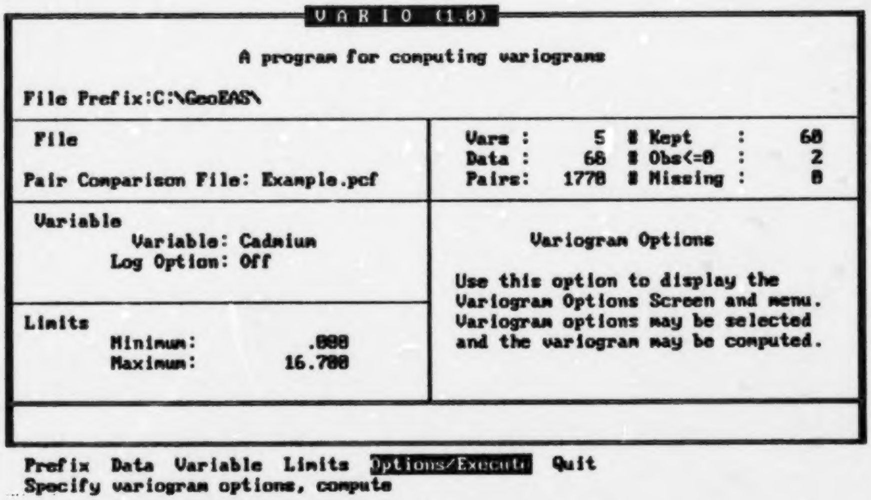
## 10.2 DATA LIMITS

Vario requires that the pair comparison file contains no more than 48 variables, 1000 samples, and 16384 pairs. If there are more than 48 variables the data file may not be used. If there are more than 1000 samples only the first 1000 will be used. Up to 24 lag intervals may be defined. As many as 2000 pairs may be used for an individual lag. If more than 2000 pairs exist per lag, only the first 2000 are used.

## 10.3 THE MENU HIERARCHY

```
Vario --- Prefix
        | Data
        | Variable
        | Limits
        | Options/Execute --- Direction
        |                   | New Lags
        |                   | Change Lags
        |                   | Post Plot
        |                   | Execute  ----- Type
        |                   |              | Plot
        |                   |              | BoxPlot
        |                   |              | Lag Results ---- Histogram
        |                   |              |                | Scatter Plot
        |                   |              |                | Examine
        |                   |              |                | Write
        |                   |              |                \ Quit
        |                   |              |
        |                   |              | Model  --------- Model
        |                   |              |                | Plot
        |                   |              |                | Options -- Titles
        |                   |              |                |          | Tic Spacing
        |                   |              |                |          | Limits
        |                   |              |                |          \ Quit
        |                   |              |                \ Quit
        |                   |              \ Quit
        |                   \ Quit
        \ Quit
```

## 10.4 THE MAIN MENU



VARIO (1.0)

A program for computing variograms

File Prefix:C:\GeoEAS\

File

Pair Comparison File: Example.pcf

Vars : 5 # Kept : 60
Data : 60 # Obs<=0 : 2
Pairs: 1770 # Missing : 0

Variable
Variable: Cadmium
Log Option: Off

Variogram Options

Use this option to display the Variogram Options Screen and menu. Variogram options may be selected and the variogram may be computed.

Limits
Minimum: .000
Maximum: 16.700

Specify variogram options, compute

Figure 10-1 Vario Main Screen

The Main screen and menu (shown in Figure 10-1) has options to allow specification of the pair comparison file, the selection of the variable to be used with associated options, and the variable limits. The menu line appears as follows:

```
Prefix  Data  Variable  Limits  Options/Execute  Quit
```

**Prefix**

The Prefix option is used to enter the prefix for file names.

**Data**

The Data option is used to enter the pair comparison file name. The pair comparison file contains distances, directions and pair pointers for pairs of (2D) sample points in a Geo-EAS data file. This file is produced by the program Prevar and is a binary (non-readable) file, to conserve disk space.

**Variable**

The Variable option allows for the selection of the variable that is to be used to compute the variogram. The choices available are the variable names as stored in the pair comparison file. When the variables are selected the input data are read from the data file and defaults are computed for sample value limits and lag spacing. If and error occurs while reading the file an error message is displayed. The screen fields accessed from this option are:

Variable - A toggle field for selecting the variable whose values are used as the sample values. The default Variable is the third variable in the pair comparison file.

Log Option - A two valued toggle field to enable or disable a logarithmic transformation of the samples. The choices available are "On" (use logarithmic scaling), and "Off". The default is "Off".

**Limits**

The Limits option allows you to enter the values that specify the limits for the sample values. The screen fields accessed from this option are:

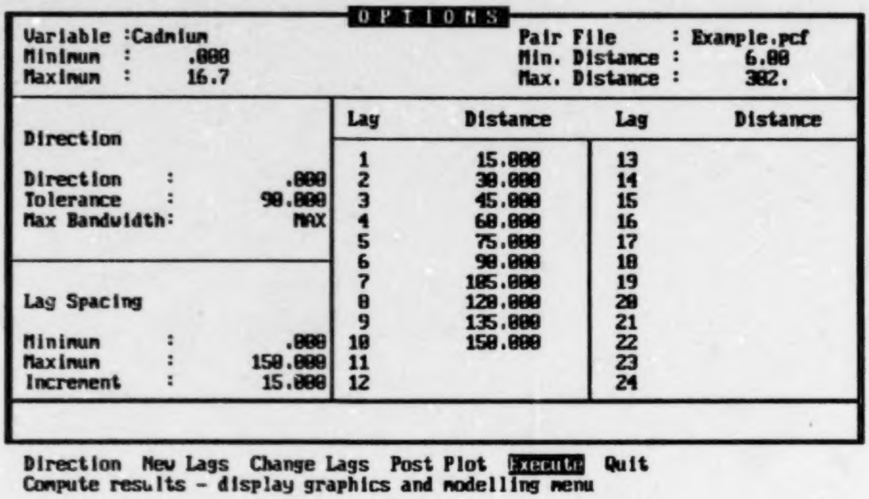
Minimum - A numeric field for entering the minimum variable value to use in computation. The default value is the minimum value of the variable selected.

Maximum - A numeric field for entering the maximum variable value to use in computation. The default value is the maximum value of the variable selected.

**Options/Execute**

The Options/Execute option provides access to the Options screen and menu (Figure 10-2), described below.

## 10.5 THE OPTIONS MENU



```
                                   OPTIONS
Variable :Cadmium                                   Pair File      : Example.pcf
Minimum  :      .000                                Min. Distance  :      6.00
Maximum  :     16.7                                 Max. Distance  :      302.

                                 Lag     Distance       Lag      Distance
Direction
                                  1       15.000        13
Direction      :          .000    2       30.000        14
Tolerance      :        90.000    3       45.000        15
Max Bandwidth:             MAX    4       60.000        16
                                  5       75.000        17
                                  6       90.000        18
                                  7      105.000        19
Lag Spacing                       8      120.000        20
                                  9      135.000        21
Minimum        :          .000   10      150.000        22
Maximum        :       150.000   11                     23
Increment      :        15.000   12                     24

Direction  New Lags  Change Lags  Post Plot  Execute  Quit
Compute results - display graphics and modelling menu
```

Figure 10-2    Vario Options Screen

The Options screen and menu (Figure 10-2) provides a means to specify variogram options, view a post plot of the data and compute the variogram results. The menu line appears as follows:

```
Direction  New Lags  Change Lags  Post Plot  Execute  Quit
```

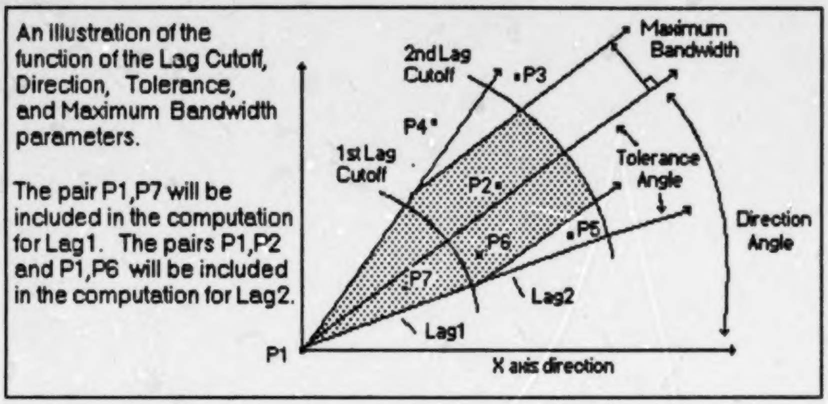
**Direction**

The Direction option allows you to specify the pair orientation (selection) criteria. Figure 10-3 illustrates how these parameters affect the grouping of pairs within a lag interval. The screen fields accessed from this option are:

Direction - A numeric field for entering the pair direction in trigonometric degrees. Acceptable values range from 0 to 180 degrees (excluding 180). The default is zero degrees, which a direction parallel to the X axis.

Tolerance - A numeric field for entering the direction tolerance in trigonometric degrees. Acceptable value range from zero to 90 degrees inclusive. The default is 90 degrees. The tolerance is plus or minus. For example, a variogram computed with a direction of 90 degrees and a tolerance of 10 degrees will include all pairs with an orientation between 80 and 100 degrees.

**Max Bandwidth** - A numeric field for entering the maximum bandwidth. The maximum bandwidth is the maximum perpendicular distance from the direction centerline to the second point in a pair. The default value is MAX, meaning that no such constraint is imposed.



An illustration of the function of the Lag Cutoff, Direction, Tolerance, and Maximum Bandwidth parameters.

The pair P1,P7 will be included in the computation for Lag1. The pairs P1,P2 and P1,P6 will be included in the computation for Lag2.

Figure 10-3 An Illustration of the Direction Parameters

**New Lags**

The New Lags option allows you to choose new pair distance intervals. Pairs are included in a lag if the distance for the pair is greater than the previous cutoff value and less than the cutoff value for that lag. The screen fields accessed from this option are:

Minimum - A numeric field for entering the minimum inter-pair distance. The first lag will contain pairs strictly greater than this value.

Maximum - A numeric field for entering the maximum inter-pair distance.

Increment - A numeric field for entering the increment between lag cutoff values.

The defaults for these fields are calculated as: Minimum = 0.0, Maximum = one half the maximum interpair distance, and Increment = Maximum divided by 10.0. These values may not be appropriate for the data configuration. Once these parameters are specified, the lag cutoff distances are displayed in columns on the Options screen.

### Change Lags

The Change Lags option allows you to change the lag cutoff distances on the Options screen. This provides a means of specifying unequal lag intervals. The screen fields accessed from this option are a group of numeric fields for entering new lag cutoff values. After these have been entered the program will sort the values by increasing distance and re-display them, if necessary.

### Post Plot

The Post Plot option allows you to view a post plot of the data. This plot shows the actual locations of the sample points. Each point is labeled with a "+" character. The X and Y axes are automatically scaled and labeled. This graph is useful in determining the lag cutoff distances for the New Lags option. Figure 10-4 displays an example post plot for Example.dat.

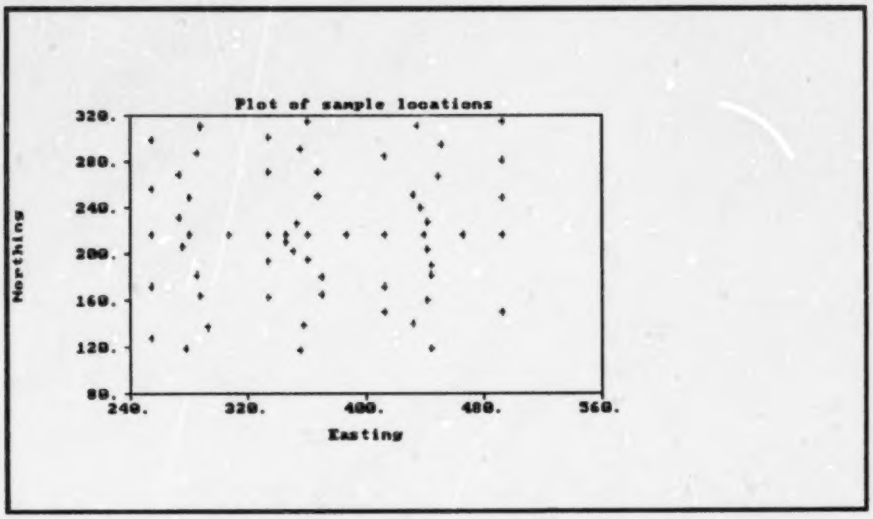
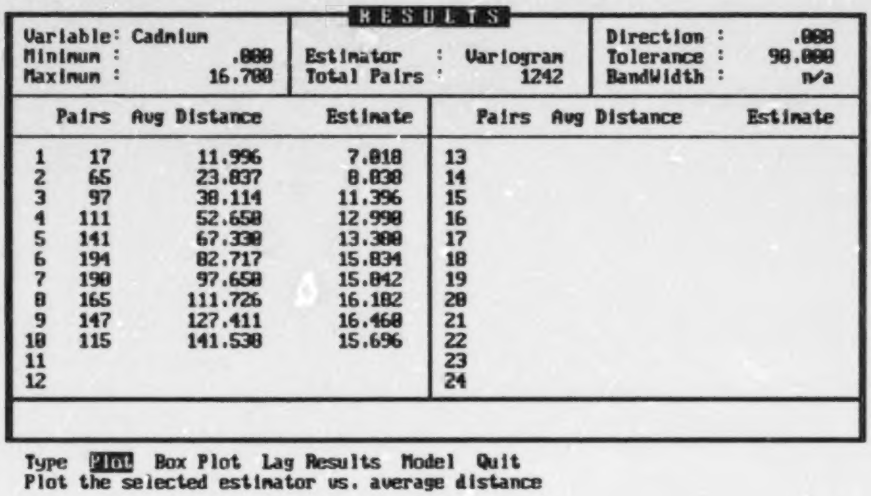


Figure 10-4 Vario Post Plot

### Execute

When the Execute option is selected the program displays the Results screen and computes the lag results before providing access to the Results screen and menu (Figure 10-5). This menu is described below.



```
                              RESULTS
Variable: Cadmium        |                              | Direction :      .000
Minimum :          .000  | Estimator   :  Variogram     | Tolerance :    90.000
Maximum :        16.700  | Total Pairs :       1242     | BandWidth :       n/a

    Pairs  Avg Distance      Estimate       Pairs  Avg Distance       Estimate

 1    17        11.996        7.018    13
 2    65        23.837        8.038    14
 3    97        38.114       11.396    15
 4   111        52.650       12.990    16
 5   141        67.330       13.300    17
 6   194        82.717       15.834    18
 7   190        97.650       15.042    19
 8   165       111.726       16.102    20
 9   147       127.411       16.460    21
10   115       141.530       15.696    22
11                                     23
12                                     24

Type  Plot  Box Plot  Lag Results  Model  Quit
Plot the selected estimator vs. average distance
```

Figure 10-5 Vario Results Screen

The Results screen and menu (Figure 10-5) has options to select the type of estimator to be computed, to view a variogram and box plots, to recompute detailed results for a specific lag, and to display the Modeling screen and menu. The menu line appears as follows:

```
Type  Plot  Box Plot  Lag Results  Model  Quit
```

## Type

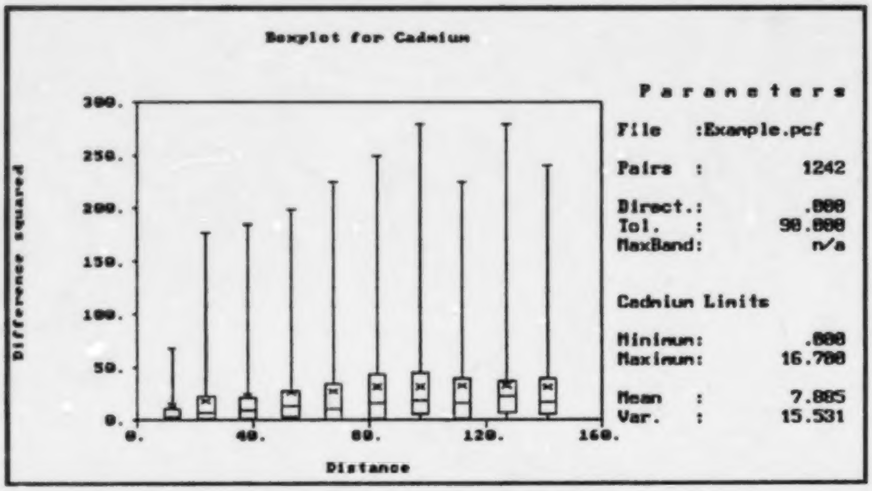
The Type option allows for the selection of the type of estimator to display and model. The screen field accessed from this option is a toggle field. The choices available are: "Variogram", "Relative", "Madogram", and "Non-Ergodic". The default is "Variogram". See the glossary for a definition of these terms.

## Plot

The Plot option allows you to view a variogram plot of the selected estimator. The distance (h) is plotted along the horizontal axis, and the variogram is plotted on the vertical axis. The type of estimator and the variable name are displayed as the graph title. Vertical and horizontal axes scaling and the tick mark spacing are calculated by the program. Displayed on the right side of the graph are the number of pairs, the lag minimum and maximum, the direction, tolerance and maximum bandwidth, the sample limits, and the mean and variance of the sample values. An example graph is displayed in Figure 10-12 near the Plot option in the Modeling screen.

### Box Plot

The Box Plot option allows you to view a variogram boxplot, displayed in Figure 10-6. This is a plot which displays statistical information about each lag. The vertical lines represent the range of values in the lag, with the minimum value at the bottom and the maximum value at the top. The rectangle superimposed over the vertical range line is the inter-quartile range. The bottom on this rectangle is the first quartile, and the top is the third quartile. Therefore, 50% of the data falls within the range represented by the rectangle. The mean is represented by "x" and the median is represented by the horizontal line through the rectangle. The distance (h) is plotted along the horizontal axis, and the difference squared is plotted on the vertical axis. The variable name is displayed in the title of the graph. Vertical and horizontal axes scaling and the tick mark spacing are calculated by the program. Displayed on the right side of the graph is the number of pairs, the lag minimum and maximum, the direction, tolerance and max bandwidth, the variable minimum and maximum, and the mean and variance of the data.



```
Parameters

File    :Example.pcf

Pairs   :          1242

Direct.:           .000
Tol.    :        90.000
MaxBand:            n/a

Cadmium Limits

Minimum:           .000
Maximum:         16.700

Mean    :         7.885
Var.    :        15.531
```

Figure 10-6    Vario Box Plot

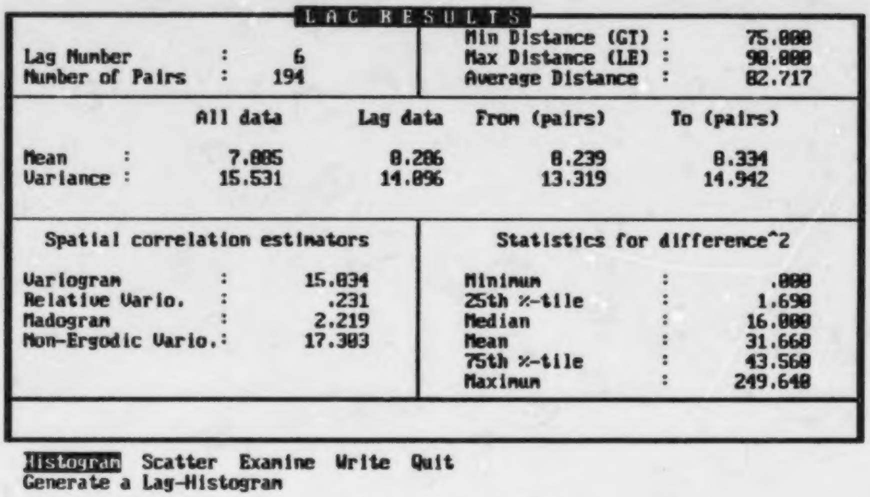
### Lag Results

When Lag Results option is selected you will be prompted to select a lag number before access is provided to the Lag Results screen and menu. This is accomplished by using the <up> and <down> keys to move the cursor bar to the desired lag number and pressing <enter>. See the section on the Lag Results menu below for more information.

### Model

The Model option provides access to the Model screen and menu. See the section on the Modeling menu below for more information.

## 10.7 THE LAG RESULTS MENU



```
                                 LAG RESULTS
                                        Min Distance (GT) :        75.000
Lag Number         :      6             Max Distance (LE) :        90.000
Number of Pairs    :    194             Average Distance  :        82.717

                    All data        Lag data   From (pairs)      To (pairs)

Mean      :            7.005           8.206          8.239           8.334
Variance  :           15.531          14.096         13.319          14.942

  Spatial correlation estimators          Statistics for difference^2

Variogram            :      15.034      Minimum          :              .000
Relative Vario.      :        .231      25th %-tile      :             1.690
Madogram             :       2.219      Median           :            16.000
Non-Ergodic Vario.:         17.303      Mean             :            31.660
                                        75th %-tile      :            43.560
                                        Maximum          :           249.640

Histogram  Scatter  Examine  Write  Quit
Generate a Lag-Histogram
```

Figure 10-7    Vario Lag Results Screen

The Lag Results screen and menu has options to allow you to view detailed results for a specific lag. The menu line appears as follows:

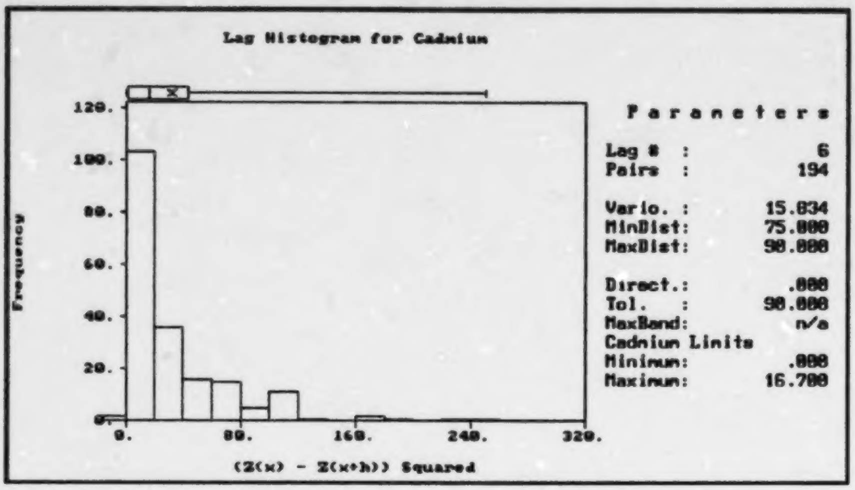
Histogram  Scatter  Examine  Write  Quit

**Histogram**

The Histogram option allows you to view a lag-histogram plot. The bars on the histogram represent the number of squared differences (increments Z(x)-Z(x+h)) in each histogram class. A box plot is appears at the top of the graph to display the frequency distribution of the entire set of differences. The variable name is displayed in the title of the graph. Vertical and horizontal axes scaling and the tick mark spacing are calculated automatically by the program. Displayed on the right side of the graph is the lag number, the number of pairs, the variogram value, the minimum and maximum distance used in computing the lag, the direction, tolerance and maximum bandwidth, and the sample value limits. An example lag-histogram plot is displayed in Figure 10-8.

**Scatter**

The Scatter option allows you to view a lag-scattergram. This is a plot of pairs of sample values. Every pair of sample values is represented as a point in the scatter plot, where the X coordinate is the value of the first point in the pair and the Y coordinate is the value of the second point in the pair. Points are plotted for all pairs in the lag, subject to the limits criteria (direction, tolerance, bandwidth, sample value limits and interpair distance) which have been specified. Displayed on the right side of the graph is the lag number, the number of pairs, the variogram value, the minimum and maximum distance, the direction, tolerance, and maximum bandwidth, and the sample value limits. Figure 10-9 displays an example lag-scattergram.



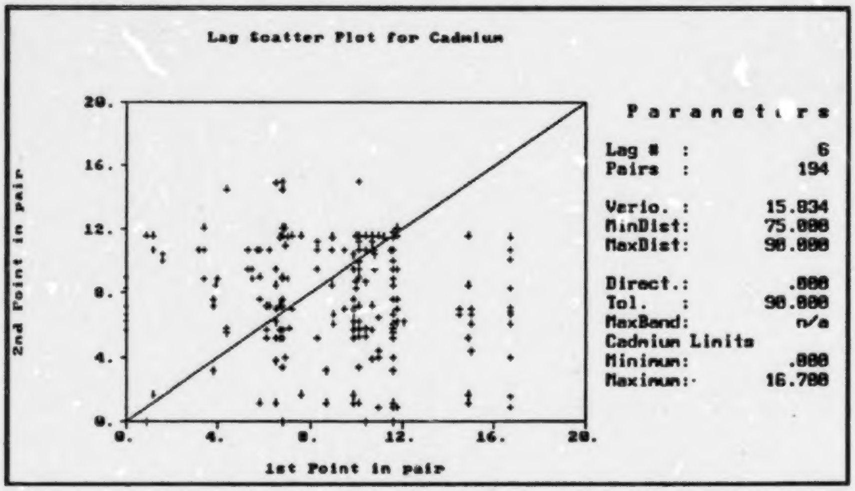
Parameters

Lag # : 6
Pairs : 194

Vario. : 15.834
MinDist: 75.000
MaxDist: 90.000

Direct.: .000
Tol. : 90.000
MaxBand: n/a
Cadmium Limits
Minimum: .000
Maximum: 16.700

Figure 10-8 Vario Lag-Histogram



Parameters

Lag # : 6
Pairs : 194

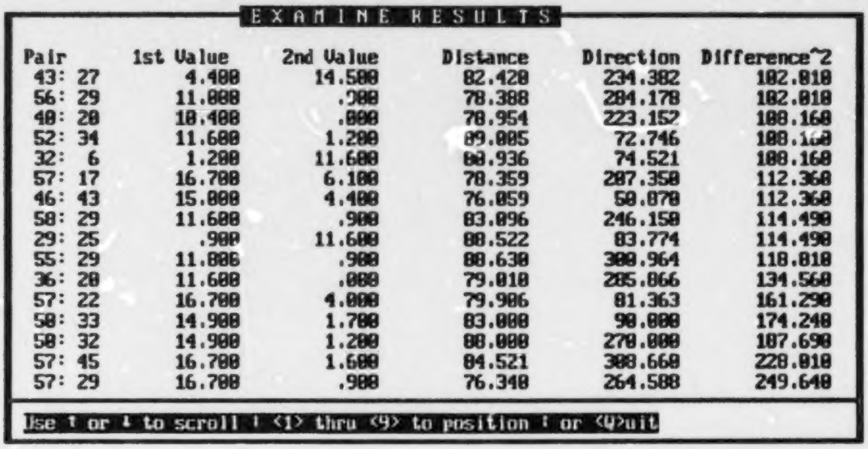
Vario. : 15.834
MinDist: 75.000
MaxDist: 90.000

Direct.: .000
Tol. : 90.000
MaxBand: n/a
Cadmium Limits
Minimum: .000
Maximum: 16.700

Figure 10-9 Vario Lag-Scattergram

**Examine**

The Examine provides access to the Examine Lag Results screen, displayed in Figure 10-10. The Examine Results screen displays in a tabular form a pair index number, the first and second values, the distance, the direction, and the difference squared for each pair in the lag. These are sorted in order of difference squared. You can use the arrow keys or the <1> to <9> keys to scroll to a position on the screen. Press <End> to position the list at the largest squared difference and <home> to view the smallest. Type <q> to clear the screen and return to the Lag Results menu.



```
                            EXAMINE RESULTS
Pair      1st Value     2nd Value      Distance     Direction  Difference^2
 43: 27       4.400        14.500        82.420       234.382       102.010
 56: 29      11.000          .900        78.300       284.170       102.010
 40: 20      10.400          .000        70.954       223.152       100.160
 52: 34      11.600         1.200        89.005        72.746       100.160
 32:  6       1.200        11.600        80.936        74.521       100.160
 57: 17      16.700         6.100        70.359       207.350       112.360
 46: 43      15.000         4.400        76.059        50.070       112.360
 58: 29      11.600          .900        83.096       246.150       114.490
 29: 25        .900        11.600        80.522        83.774       114.490
 55: 29      11.006          .900        80.630       300.964       110.010
 36: 20      11.600          .000        79.010       285.066       134.560
 57: 22      16.700         4.000        79.906        81.363       161.290
 50: 33      14.900         1.700        83.000        90.000       174.240
 50: 32      14.900         1.200        80.000       270.000       187.690
 57: 45      16.700         1.600        84.521       300.660       228.010
 57: 29      16.700          .900        76.340       264.500       249.640
Use ↑ or ↓ to scroll | <1> thru <9> to position | or <Q>uit
```

Figure 10-10 Vario Examine Lag Results Screen

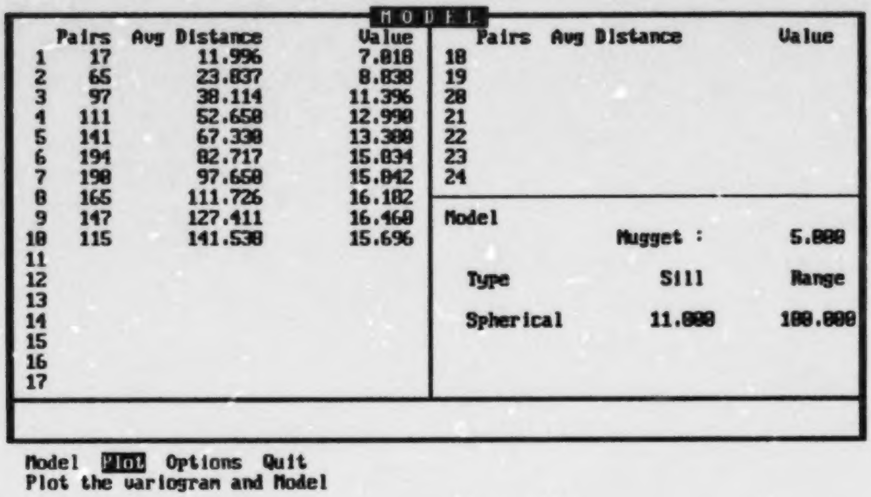
### Write

The Write option allows you to save the lag results in a Geo-EAS data file. The Variable, From___, To___ Distance, Direction, Difference and Difference^2 will saved in a file. The file name is entered on the message line, when the Write option is selected. The default file name is "LagResult.dat". If the file already exists, a Yes/No prompt provides an alternative to quit or proceed. The lag results file may be used with other Geo-EAS programs for a more detailed analysis of the pair information.

## 10.8 THE VARIOGRAM MODELING MENU

The Variogram Modeling screen and menu has options to allow you to specify the variogram model to display, the graph options, and to plot the variogram estimates and the specified model. This screen is displayed in Figure 10-11. The menu line appears as follows:

```
Model  Plot  Options  Quit
```



```
                                   MODEL
    Pairs  Avg Distance          Value     Pairs  Avg Distance        Value
 1     17        11.996          7.010  18
 2     65        23.837          8.838  19
 3     97        38.114         11.396  20
 4    111        52.650         12.990  21
 5    141        67.330         13.300  22
 6    194        82.717         15.034  23
 7    190        97.650         15.042  24
 8    165       111.726         16.102  Model
 9    147       127.411         16.460
10    115       141.530         15.696           Nugget :           5.000
11
12                                       Type               Sill       Range
13
14                                       Spherical        11.000     100.000
15
16
17

Model  Plot  Options  Quit
Plot the variogram and Model
```

Figure 10-11   Variogram Modeling Screen

**Model**

The Model option allows you to edit or enter the parameters for the variogram model. Up to four nested variogram structures and a "nugget" component can be included in the model. The screen fields access from this option are:

Nugget - A numeric field for entering the nugget effect. The value entered must be greater than or equal to 0.

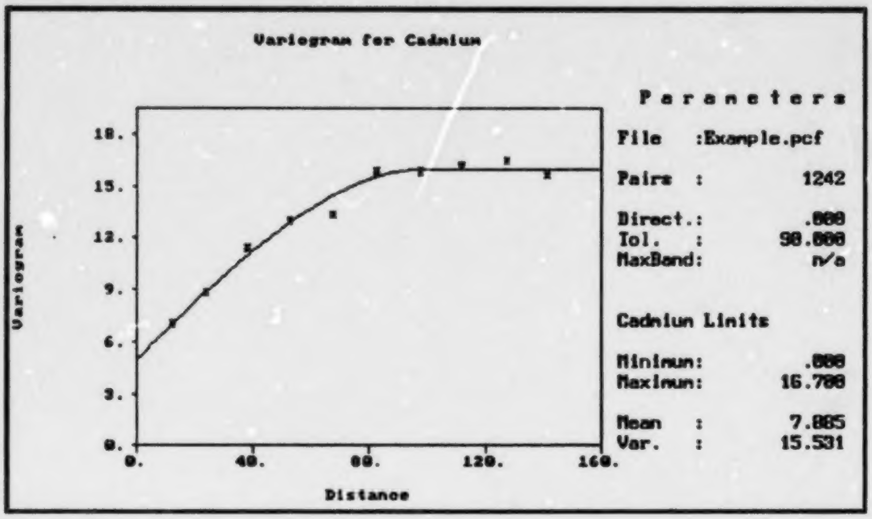
Type - Four toggle fields used for selecting the type of variogram structure. The choices available for each are "Spherical", "Gaussian", "Exponent", "Linear", and "          " If "          " is selected the structure will be ignored.

Sill - Four numeric fields for entering the sill for each structure.

Range - Four numeric fields for entering the range of influence of the structure. The range of the variogram structure. The range in a spherical model is the distance at which the model curve becomes horizontal. In a gaussian and exponential model the range parameter entered is a "practical range" at which the model attains 95% of its maximum value. In the linear model, the range and sill are used to define the slope of a linear structure. The practical effect of this is that the model type can be changed without changing the "apparent range" of the model curve.

**Plot**

The Plot option allows you to view a plot of the estimates with specified model superimposed. An example plot is displayed in Figure 10-12. The distance is plotted along the horizontal axis, and the variogram is plotted against the vertical axis. The type of estimator and the variable name is displayed as the graph title. Vertical and horizontal axis scaling and tick mark spacing are calculated by the program. Displayed on the right side of the graph are the total number of pairs, the minimum and maximum distances, the direction, tolerance and maximum bandwidth, the sample value limits, and the mean and variance of the sample values. Press <q> to clear the screen and access the Variogram Modeling menu.



Parameters

File :Example.pcf

Pairs : 1242

Direct.: .000
Tol. : 90.000
MaxBand: n/a

Cadmium Limits

Minimum: .000
Maximum: 16.700

Mean : 7.005
Var. : 15.531

Figure 10-12 Plot of Variogram with Model Curve

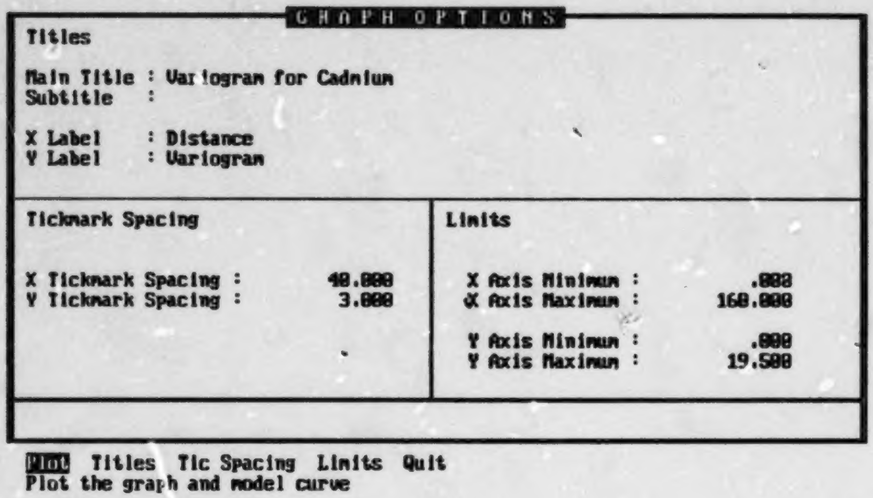
**Options**

The Options option provides access to the Graph Options screen and menu, displayed in Figure 10-13.

## 10.9 THE GRAPH OPTIONS MENU

The Graph Options screen and menu (Figure 10-13) has options to select the graph titles and labels, the spacing of the tick marks, and the graph limits for the graph produced with the Plot option of the Variogram Modeling menu. The menu line appears as follows:

```
Titles  Tic Spacing  Limits  Quit
```



```
                         GRAPH OPTIONS
Titles

Main Title : Variogram for Cadmium
Subtitle   :

X Label    : Distance
Y Label    : Variogram

Tickmark Spacing                    Limits

X Tickmark Spacing :      40.000     X Axis Minimum :        .000
Y Tickmark Spacing :       3.000     X Axis Maximum :     160.000

                                     Y Axis Minimum :        .000
                                     Y Axis Maximum :      19.500

Plot  Titles  Tic Spacing  Limits  Quit
Plot the graph and model curve
```

Figure 10-13   Variogram Graph Options Screen

### Titles

The Titles option allows you to enter the title and labels for the graph. The screen fields accessed from this option are:

Title - An alphanumeric field which may contain up to 60 characters each, for the title on the graph. The default title contains the type of estimator and the variable name.

Subtitle - An alphanumeric field which may contain up to 60 characters for the graph subtitle.

X Label - An alphanumeric field which may contain up to 60 characters for the X axis label. The default label is "Distance".

Y Label - An alphanumeric field which may contain up to 60 characters for the Y axis label. The default label is the type of estimator selected.

### Tic Spacing

The Tic Spacing option allows the specification of the spacing of tick marks on the X and Y axes. The screen fields accessed from this option are:

X Tickmark Spacing - A numeric field for entering the spacing between the X axis tickmarks.

Y Tickmark Spacing - A numeric field for entering the spacing between the Y axis tickmarks.

**Limits**

The Limit option allows you to specify the limits for the X and Y axes. The screen fields accessed from this option are:

X Axis Minimum - A numeric field for entering the minimum coordinate value to be used on the X axis. The default value is zero.

X Axis Maximum - A numeric field for entering the maximum coordinate value to be used on the X axis. The default value is the maximum distance calculated by the program.

Y Axis Minimum - A numeric field for entering the minimum coordinate value to be used on the Y axis. The default value is zero.

Y Axis Maximum - A numeric field for entering the maximum coordinate value to be used on the Y axis. The default value is the maximum variogram value calculated by the program.

# SECTION 11

# XVALID

## 11.1 WHAT XVALID DOES

The name Xvalid stands for "cross-validation". Cross-validation involves estimating values at each sampled location in an area by kriging with the neighboring sample values (excluding the value of the point being estimated). The estimates are compared to the original observations in order to test if the hypothetical variogram model and neighborhood search parameters will accurately reproduce the spatial variability of the sampled observations. The estimated values, associated kriging errors, residuals, and other useful statistics are displayed on a summary screen. Scatter plots and histograms may be obtained for a quick summary of these results. Results may be stored in a Geo-EAS data file for further analysis.

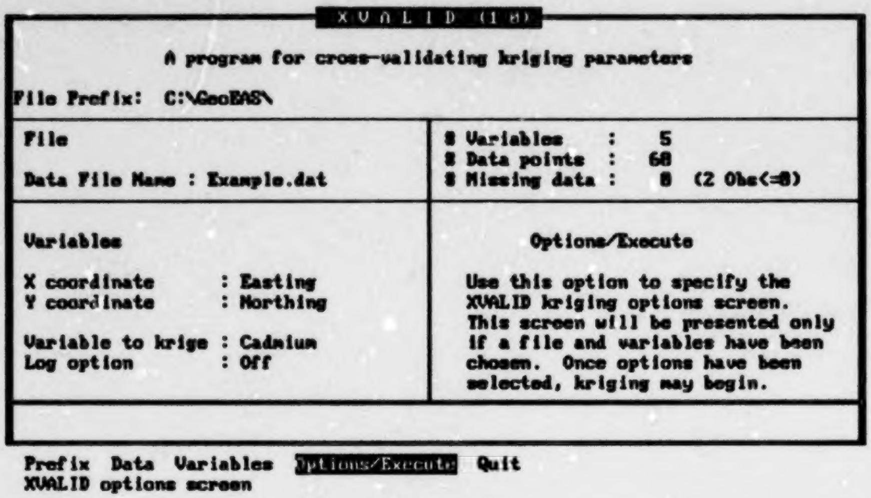
## 11.2 DATA LIMITS

Xvalid requires that the input data file contains at least 3 but no more than 48 variables. Two of these variables must represent the coordinates of sample locations. No more than 1000 samples may reside in the data file. If more than this number are encountered, only the first 1000 values will be used for cross-validation.

## 11.3 THE MENU HIERARCHY

```
Xvalid --- Prefix
         | Data
         | Variables
         | Options/Execute ---- Type
         \ Quit               | Search
                              | Model
                              | Execute ---- Error Map
                              | Debug      | Scatter Plot
                              \ Quit       | Histogram
                                           | Write
                                           | Examine
                                           \ Quit
```

## 11.4 THE MAIN MENU



```
XVALID (1.0)

              A program for cross-validating kriging parameters

File Prefix:  C:\GeoEAS\

 File                                    # Variables    :    5
                                         # Data points  :   68
 Data File Name : Example.dat            # Missing data :    0  (2 Obs<=0)

 Variables                                     Options/Execute

 X coordinate       : Easting             Use this option to specify the
 Y coordinate       : Northing            XVALID kriging options screen.
                                          This screen will be presented only
 Variable to krige  : Cadmium             if a file and variables have been
 Log option         : Off                 chosen.  Once options have been
                                          selected, kriging may begin.

 Prefix  Data  Variables  Options/Execute  Quit
 XVALID options screen
```

Figure 11-1    Xvalid Main Screen

The Main screen and menu for Xvalid, shown in Figure 11-1, provides options to specify the file prefix, the input data file and variables, and to access the Options/Execute menu. The menu line appears as follows:

```
Prefix  Data  Variables  Options/Execute  Quit
```

### Prefix

The Prefix option is used to enter the prefix for the data file name.

### Data

The Data option is used to specify the name of the Geo-EAS data file to be used for cross-validation. This file must contain at least three variables consisting of two coordinates and a sampled value.

### Variables

The Variables option is used to select the coordinate and sample value variables. They are selected from toggle fields which contain the variable names from the specified data file. The data file is accessed when these variables are selected. If an error occurs while reading the data file an error message will be generated. The screen fields accessed from this option are:

X Coordinate - A toggle field for selecting the variable whose values represent the X coordinates for sample points. The default X Coordinate is the first variable in the data file.

Y Coordinate - A toggle field for selecting the variable whose values will be used as the Y coordinates for sample points. The default Y Coordinate is the second variable in the file.

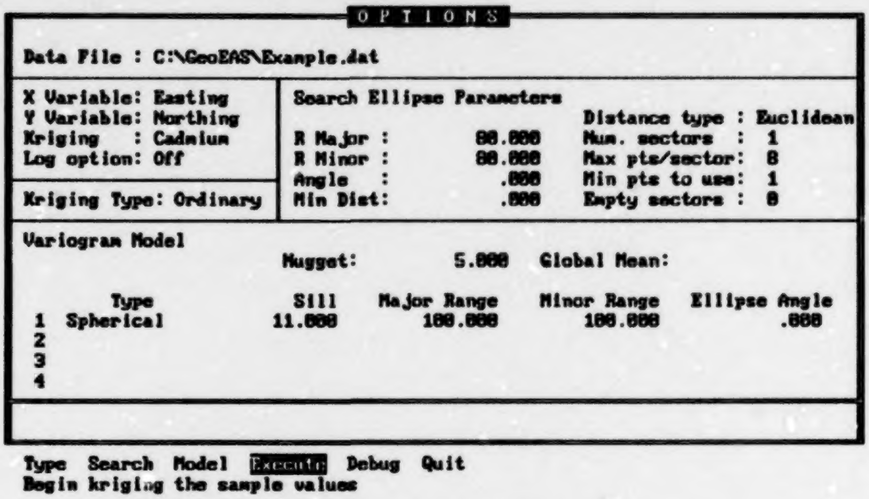
Variable to Krige - A toggle field for selecting the variable to be estimated. The default is the third variable in the data file.

Log Option - A two-valued (On/Off) toggle field for enabling or disabling the Log Option. If the Log Option is set to "On", kriging will be performed on the natural log of the sample values. If it is set to "Off", no log transformation will occur. The default value for the Log Option is "Off".

### Options/Execute

The Options/Execute option provides access to the Options screen and menu. See the section below for more information.

## 11.5 THE OPTIONS MENU



```
                               OPTIONS
Data File : C:\GeoEAS\Example.dat

X Variable: Easting         Search Ellipse Parameters
Y Variable: Northing                               Distance type : Euclidean
Kriging   : Cadmium         R Major :      80.000  Num. sectors  : 1
Log option: Off             R Minor :      80.000  Max pts/sector: 8
                            Angle   :        .000  Min pts to use: 1
Kriging Type: Ordinary      Min Dist:        .000  Empty sectors : 0

Variogram Model
                       Nugget:         5.000   Global Mean:

      Type              Sill    Major Range   Minor Range   Ellipse Angle
 1  Spherical          11.000     100.000       100.000          .000
 2
 3
 4

Type  Search  Model  Execute  Debug  Quit
Begin kriging the sample values
```

Figure 11-2    Xvalid Options Screen

The Options screen and menu, shown in Figure 11-2, has the options to specify the parameters to be used for kriging, and to initiate the cross-validation process. The menu line appears as follows:

Type   Search   Model   Execute   Debug   Quit

### Type

The Type field is a toggle field used for selecting the type of kriging used in cross-validation. The choices are "Ordinary", and "Simple". If "Ordinary" is chosen, ordinary point kriging will be performed. If "Simple" kriging is chosen, simple kriging is performed and a value must be entered for the Global Mean when the Model option is selected.

**Search**

The Search option provides a means of controlling the neighborhood search used during kriging. Parameters may be specified to define an elliptical search area. Constraints may be placed upon the number of sectors and the number of samples to be retained in each sector of the search area, and the type of distance measure to use when eliminating neighbors from a search sector. Figure 11-3 depicts the search parameters which define the shape of the search ellipse. The screen fields accessed from this option are:

R Major - a numeric field for indicating the length of the major radius (half the length of the longest axis) of the search ellipse.

R Minor - a numeric field for indicating the length of the minor (shortest) radius of the search ellipse. This value must be less than or equal to R Major, non-zero, and non-negative. The default value is the value given for R Major. If R Major is equal to R Minor, the search area will be a circle.

Angle - a numeric field for indicating the orientation of the search ellipse. It is given in trigonometric degrees in the range from zero up to (but not including) 180, and indicates the angle between the longest axis of the ellipse (specified by R Major) and the sample coordinate X axis. If R Minor is equal to R Major, a circle search is used and the Angle parameter is ignored.

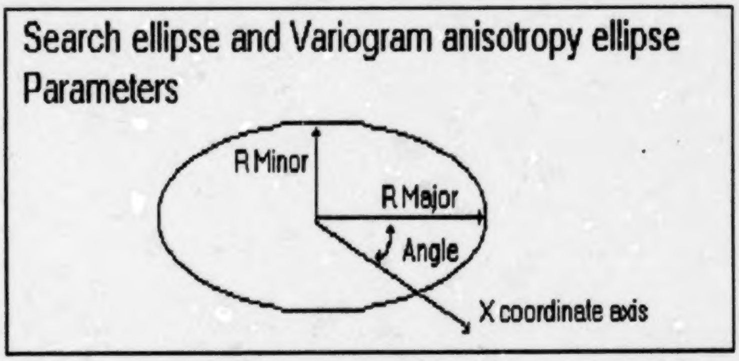


Figure 11-3 Search (and Variogram) Ellipse Parameters

Min. Dist. - a numeric field for specifying the minimum distance from the estimated sample location to the nearest neighbor sample. If a minimum distance of zero (the default) is specified, then any neighboring sample will be used, subject to the complete set of search constraints.

Distance Type - a two valued toggle field for selecting the type of distance measure to use when eliminating neighbors. The choices available are "Euclidean" (the default), and "Variogram". Neighboring samples are eliminated from consideration when the Max Pts/Sector (Maximum points per sector) criterion is exceeded in a given sector. If this should occur, only the "closest" neighbors are kept. If "Euclidean" distance type is chosen, neighbors are eliminated based upon the euclidean distance from the point to be estimated ellipse center. If "Variogram" distance is chosen, the variogram function value (as specified by the Model parameters) for the computed distance is used as the criterion for elimination of neighbors.

Num. Sectors - a toggle field for selecting how many sectors in which to divide the search ellipse. The choices available are "1" (the default), "4", and "8". The combination of the Number of Sectors, and the Max Points per Sector parameters indicate the maximum number of samples to be used for kriging. This parameter also serves to indicate the number of groups to use for classification of neighbors. The search ellipse is divided into the chosen number of equally-sized sectors. If a sample is found to be within the search ellipse, it is flagged with a sector number. These sector numbers and sample distances are used for elimination of samples which exceed the Max Points per Sector criterion.

Max. Pts/Sector - a toggle field for selecting the maximum number of points which a sector may contain. The choices range from "1" to a maximum which depends on the number of sectors chosen. If one sector is specified, up to 24 neighboring points may be used. If four or eight sectors are selected, the choices are constrained such that a maximum of 64 neighbors may be retained. If the number of neighbors in a sector exceeds the specified value, the "farthest" samples (as determined by Distance Type) are eliminated from consideration.

Min Pts. to Use - a toggle field for selecting the minimum number of neighboring samples to use for kriging. The default value or this parameter is "1". If fewer than the specified number are found kriging is not performed and a missing value is generated for the estimate and kriging standard deviation.

Empty Sectors - a toggle field for selecting the maximum allowable number of consecutive sectors with no neighbors. The choices available are determined by the Number of Sectors parameter. If one sector is chosen, then this field is disabled. If more than the specified number of consecutive sectors are empty, no value is kriged; missing values are generated in place of an estimate and kriging standard deviation.

## Model

The Model option allows specification of the variogram model to use when kriging. Screen fields are provided for a nugget effect value and up to four nested variogram structures. Each structure is specified with a structure type, a sill value, and an ellipse of influence. If simple kriging is chosen an additional field is provided for entering the Global Mean. Each of the four structures has five associated screen fields. Selecting the Model option will cause a cursor bar to appear in the upper left corner of the models area. The arrow keys may be used to move the cursor bar to fields in the Model area. To exit the Model area, move the cursor bar out of the top or off to the left of the area, using <left>, or <up>. If any errors are made when entering variogram model parameters an error message will be displayed and the cursor bar will be placed at the problem field. The major and minor ranges, and the angles for the additive variogram structures defined in this parameter group are similar to the search ellipse ranges and angles. Figure 11-3 illustrates how these parameters define the shape of the ellipse. The screen fields accessed from this option are:

Nugget - a numeric field for entering the nugget value for the variogram model. Only values greater than or equal to zero may be entered. The default value is zero.

Global Mean - a numeric field for specifying the global mean for simple kriging. If ordinary kriging is chosen this field is disabled and cannot be accessed. The default value for the global mean is zero.

The following five fields are present for each of the four nested variogram structures:

Type - a toggle field for indicating the type of the structure. The toggle field choices for type are "      " (none), "Spherical", "Gaussian", "Exponential", "Linear". The default type for all four structures is "none". If a structure is entered and the type is subsequently changed to "none" the structure will be deleted from the variogram model. The order of the variogram structures on the screen is unimportant; neither do they need to be in a contiguous order on the screen.

Sill - a numeric field for entering the sill value for a variogram structure. A non-zero, non-negative value is required here. In a linear variogram structure the "sill" must be chosen so that the corresponding "range" parameter value(s) will result in the desired slope(s); the actual model continues to increase indefinitely with distance.

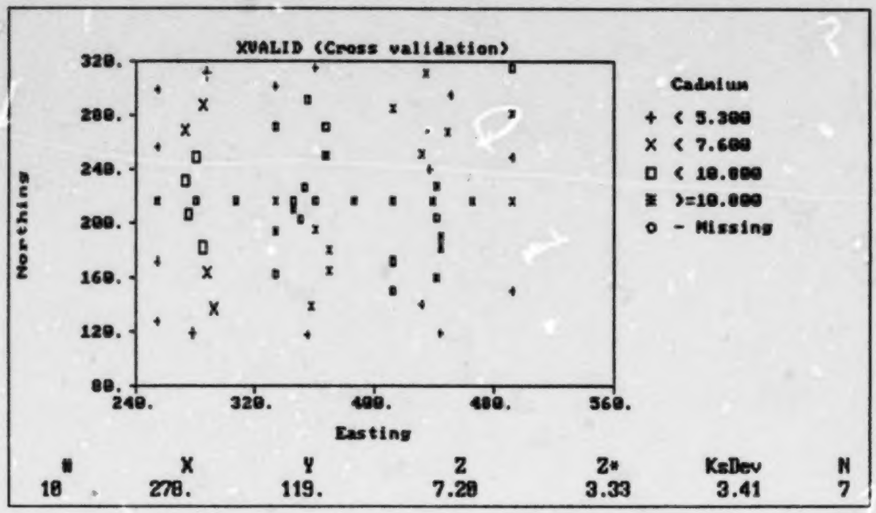
Major Range - a numeric value for entering the longest range of influence of the variogram structure. The Major Range must be non-zero, and non-negative. This may be thought of as similar to the R Major parameter described in the Search option above. In fact, the variogram ellipse of influence is defined exactly as the search ellipse: with two ranges (radii) and an angle. Note that the second ellipse is used to select a reasonable subset of neighbors for efficient kriging - it has no relationship to the variogram model ellipse(s).

Minor Range - a numeric field for indicating the length of the minor (shorter) range of the variogram ellipse. This value must be less than or equal to the Major Range, non-zero, and non-negative. The default value is the Major Range value. If the two ranges are equal, an isotropic variogram structure is defined. If they are not equal, the two ranges are used to determine the anisotropy ratio.

Ellipse Angle - a numeric field for indicating the orientation of the ellipse for the variogram structure. It is given in trigonometric degrees in the range from zero up to (but not including) 180, and indicates the angle between the longest axis of the ellipse (specified by the Major Range) and the sample coordinate X axis. If the two ranges are equal (isotropic structure) then the angle is ignored.

## Execute

The Execute option is used to initiate kriging. All parameters must be specified before kriging may begin. Several "Debug Options" (described below) are enabled or disabled with the <caps-lock>, the <num-lock>, and the <scroll-lock> keys. These keys are used to toggle the debug displays on or off. If your keyboard has status lights for the keys, it is easy to determine the state of each key. It is important to disable all three Debug Options prior to using the Execute option, or intermediate results screens will be generated and kriging will proceed more slowly. If your personal computer is equipped with the proper graphics hardware, a graphics display is generated (Figure 11-4) when the Execute option is selected. In this display the original sample locations are represented by symbols. The symbol coding is used to classify the input data into their respective quartiles. As each point is kriged the estimates and associated results are displayed at the bottom of the screen and the original symbols are over-plotted by symbols which represent the value of the estimate. On EGA equipped computer systems, the symbols are also color coded. If your computer system has no graphics capability or has a Hercules graphics card, no graph is displayed, and the results are displayed at the bottom of the Options screen. During the kriging process the debug displays (described below) may be activated or de-activated to view intermediate kriging results. Once all sample values have been kriged, a tone signals that the kriging has been completed. Pressing <q> at this time will cause the Results screen and menu (described below) to be displayed.



```
   #          X           Y              Z             Z*        KsDev      N
  10        270.        119.            7.20           3.33       3.41      7
```

Figure 11-4    Xvalid Kriging Display

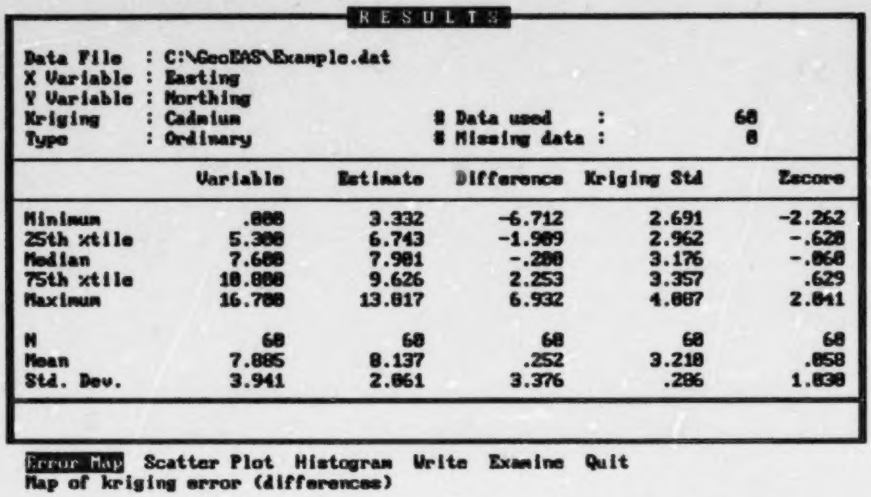
**Debug**

The Debug option is provided on the menu as a means of identifying the keys used for enabling or disabling the Debug displays. This option does not actually do anything, but moving the cursor bar to this menu option will display the Debug display names, and the corresponding <____-lock> keys which are used to activate them. These displays provide a means of looking at intermediate kriging results during the cross-validation process. If the <num-lock>, <caps-lock>, or <scroll-lock> keys are activated during kriging, the corresponding displays will be generated on the screen. To continue to the next display, <q> is pressed. To disable the generation of such screens, the corresponding keys should be de-activated. On an IBM AT- style keyboard, these three keys are accompanied by status lights which indicate that the key is "on", or "off". Refer to the section on program Krige for a detailed discussion of the debug displays.

**How to Cancel Kriging**

At any time during the kriging process, kriging may be cancelled by pressing the <ctrl> and <alt> keys, the <ctrl> and <shift> keys, or the <left shft> and <right shft> keys simultaneously and holding them down until the next point has been kriged. If this is done a message is displayed indicating that kriging has been terminated. This is useful when the debug screens reveal a problem with the search or variogram parameters and you wish to change them and re-start. It is important to remember that the "terminate kriging" keys will not work when any of the three debug display keys is active.

## 11.6 THE RESULTS MENU



```
                              R E S U L T S

Data File   : C:\GeoEAS\Example.dat
X Variable  : Easting
Y Variable  : Northing
Kriging     : Cadmium                   # Data used    :            60
Type        : Ordinary                  # Missing data :             0

                 Variable    Estimate  Difference  Kriging Std      Zscore

Minimum              .000       3.332      -6.712        2.691      -2.262
25th %tile          5.300       6.743      -1.909        2.962       -.620
Median              7.600       7.901       -.200        3.176       -.060
75th %tile         10.000       9.626       2.253        3.357        .629
Maximum            16.700      13.017       6.932        4.007       2.041

N                      60          60          60           60          60
Mean                7.005       8.137        .252        3.210        .058
Std. Dev.           3.941       2.061       3.376         .286       1.030

Error Map  Scatter Plot  Histogram  Write  Examine  Quit
Map of kriging error (differences)
```

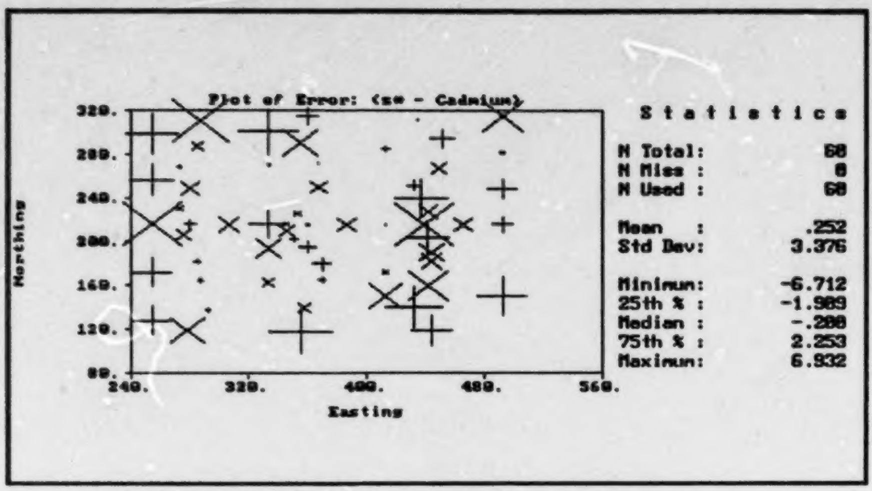
Figure 11-5    Xvalid Results Screen

The Results menu and screen, shown in Figure 11-5, is displayed when kriging has been completed. The Results screen contains information about the data file, variables, and the type of kriging used. Additionally, descriptive statistics are provided for the original sample values, the kriged estimates, the kriging standard deviations, the differences (between estimate and observed), and the zscore. The "zscore" is computed as the ratio of the difference to the kriging standard deviation. The Results menu appears at the bottom of the screen, and provides options to display several graphs, to examine the individual results, and to save the results to a Geo-EAS data file. Graph scaling, titles, and labeling are performed automatically. On a non-graphics computer system the graphs are not generated. The menu line appears as follows:

```
Error Map  Scatter Plot  Histogram  Write  Examine  Quit
```

### Error Map

The Error Map option provides a graph of the kriging error, or "Differences". An example plot is displayed in Figure 11-6. Sample locations are marked with a "+" symbol for over-estimation (Estimate-Observed > 0), and an "x" symbol for negative differences. The size of the symbol is proportional to the error, so that large positive or negative differences are easily noticed. Descriptive statistics for the differences are displayed to the right of the graph.



```
Statistics

N Total:        68
N Miss :         0
N Used :        68

Mean   :      .252
Std Dev:     3.376

Minimum:    -6.712
25th % :    -1.989
Median :     -.288
75th % :     2.253
Maximum:     6.932
```

Figure 11-6    Xvalid Error Map

**Scatter Plot**

The Scatter Plot option provides a choice of displaying one of two possible scatter plots. When this option is chosen a two-valued toggle field containing the choices "Observed vs. Estimate", and "Estimate vs. Error" is displayed on the message line. It is used to select the type of scatter plot to be displayed. Once this choice has been made the appropriate graph will be displayed. Box plots are drawn opposite to each coordinate axis to convey information about the frequency distributions of the observed values and estimates, or estimates and differences. In both types of graph "+" and "x" symbols are used to indicate positive and negative estimation errors (same as the Error Map option described above). An example plot is displayed in Figure 11-7.

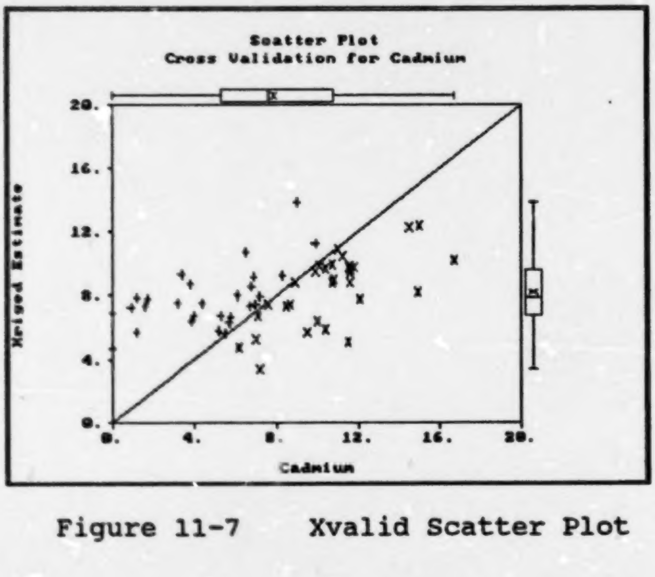


Figure 11-7    Xvalid Scatter Plot

## Histogram

The Histogram option provides a histogram (frequency distribution graph) of the estimation error. An example plot is shown in Figure 11-8. Histogram class intervals are computed automatically by the program. A box plot of the differences appears at the top of the graph. Descriptive statistics are displayed to the right of the histogram.

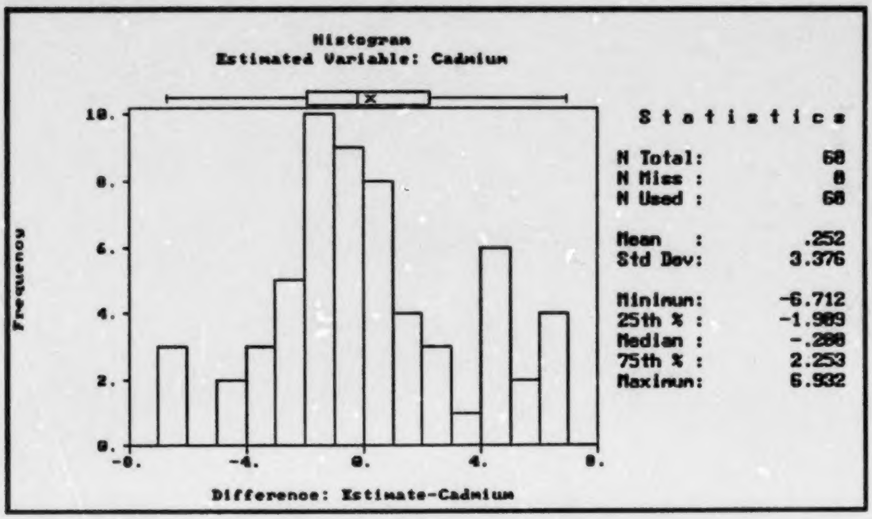


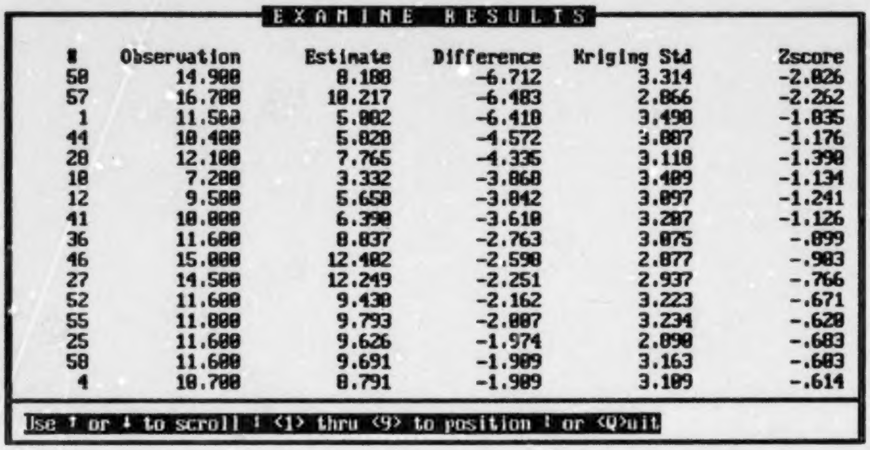
Figure 11-8    Xvalid Error Histogram

## Write

The Write option is used to store the result to a Geo-EAS data file. When this option is chosen a prompt for the file name appears on the message line. If the specified file exists, a Yes/No prompt will provide an option to overwrite, or quit. If any errors occur while saving the results to the file, appropriate error messages will be displayed on the message line. If results were successfully saved, a message will be displayed, and pressing any key will re-activate the Results menu. The file created by this option contains seven variables. The first three are the two sample coordinate variables and the sample value variable chosen for kriging. The remaining four variables are named "Zstar", "Zsdev", "Zstar-Z", and "Zscore". They contain, respectively, the estimate, the kriging standard deviation, the estimation error, and the zscore (estimation error divided by the kriging standard deviation). This file may be used with other Geo-EAS programs for further analysis.

## Examine

The Examine option provides a means of directly examining individual results of kriging on a scrolling display, called the Examine Results screen. This screen is shown in Figure 11-9. The observed values, estimates, errors, kriging standard deviations, and zscores are displayed in columns on this screen. These values are ranked in order of estimation error, so that the largest negative difference is at the top of the list, and the largest positive difference is at the bottom of the list. The leftmost column contains the sample sequence number in the input data file. The <up>, <down>, <pgup>, <pgdn>, <home>, and <end> keys may be used to position the list on the screen. The numeric keys <1> through <9> are used to scroll the list in increments of 10% (e.g. pressing <5> would position the middle of the list on the screen). The <q> key is used to exit the Examine Results screen and return to the Results screen and menu.



```
                          E X A M I N E   R E S U L T S

   #   Observation       Estimate    Difference   Kriging Std          Zscore
  58        14.900          8.188        -6.712         3.314          -2.026
  57        16.700         10.217        -6.483         2.866          -2.262
   1        11.500          5.082        -6.418         3.498          -1.835
  44        10.400          5.828        -4.572         3.887          -1.176
  20        12.100          7.765        -4.335         3.118          -1.390
  10         7.200          3.332        -3.868         3.409          -1.134
  12         9.500          5.658        -3.842         3.097          -1.241
  41        10.000          6.390        -3.610         3.207          -1.126
  36        11.600          8.837        -2.763         3.075           -.899
  46        15.000         12.402        -2.598         2.877           -.903
  27        14.500         12.249        -2.251         2.937           -.766
  52        11.600          9.438        -2.162         3.223           -.671
  55        11.800          9.793        -2.007         3.234           -.620
  25        11.600          9.626        -1.974         2.890           -.683
  58        11.600          9.691        -1.909         3.163           -.603
   4        10.700          8.791        -1.909         3.109           -.614

Use ↑ or ↓ to scroll ¦ <1> thru <9> to position ¦ or <Q>uit
```

Figure 11-9     Xvalid Examine Results Screen

## SECTION 12

## KRIGE

### 12.1 WHAT KRIGE DOES

Krige is an interactive program which performs two-dimensional kriging. A rectangular grid of kriged estimates is created and stored in a Geo-EAS data file. Contour plots may be generated from these gridded estimates with the program Conrec. Options are provided to control the type of kriging, the neighborhood search area, the grid spacing and extents, and the variogram model for each variable kriged. Up to ten variables may be kriged in each program execution. The program parameters may be stored in a parameter file and retrieved for later use. During the kriging process, debug displays may be activated or de-activated for the purpose of viewing intermediate kriging results.

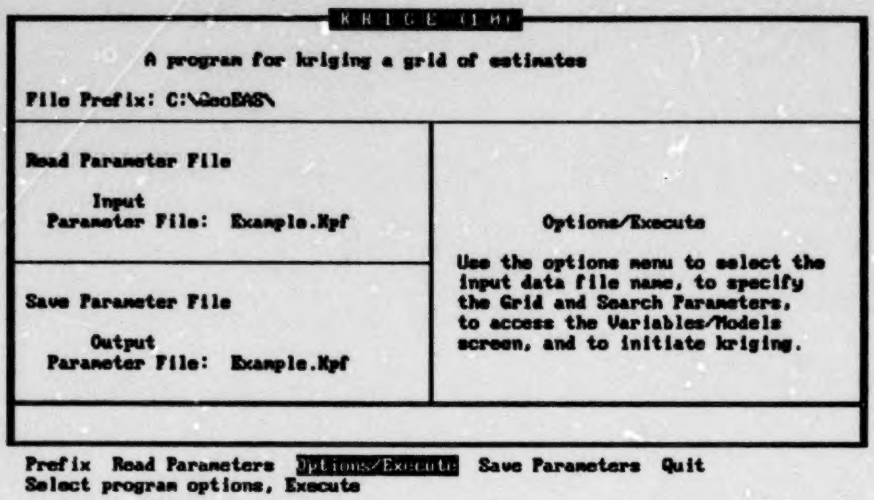
### 12.2 DATA LIMITS

Krige requires that the input data file contains at least three but no more than 48 variables. Two of these variables must represent the coordinates of sample locations. Up to ten variables may be selected for kriging. No more than 1000 samples may reside in the data file. If more than this number are encountered only the first 1000 values will be used for kriging.

### 12.3 THE MENU HIERARCHY

```
Krige --- Prefix
        | Read Parameters
        | Options/Execute ---- Data
        | Save Parameters    | Polygon
        \ Quit               | Type
                             | Grid
                             | Search
                             | Variables/Models -- New Variable
                             | Title             | Edit
                             | Execute           | Delete
                             \ Quit              \ Quit
```

## 12.4 THE MAIN MENU



```
KRIGE (1.1)

        A program for kriging a grid of estimates

File Prefix: C:\GeoEAS\

Read Parameter File

      Input
  Parameter File:  Example.Kpf                  Options/Execute

                                     Use the options menu to select the
                                     input data file name, to specify
Save Parameter File                  the Grid and Search Parameters,
                                     to access the Variables/Models
      Output                         screen, and to initiate kriging.
  Parameter File:  Example.Kpf

Prefix  Read Parameters  Options/Execute  Save Parameters  Quit
Select program options, Execute
```

Figure 12-1    Krige Main Screen

The Main screen and menu for Krige, shown in Figure 12-1, provides options to specify the file prefix, to read or save program parameter values in a parameter file, and to access the Krige Options menu, where program parameter values are specified and kriging is initiated. The menu line appears as follows:

```
Prefix  Read Parameters  Options/Execute  Save Parameters  Quit
```

**Prefix**

The Prefix option is used to enter the prefix for the data file name.

**Read Parameters**

The Read Parameters option provides a means of loading program parameter values from a parameter file. When this option is selected a prompt is issued for the Input Parameter File name. A default name is constructed from the most recently used Geo-EAS data file name using the file extension "kpf" (krige parameter file). Once the name has been specified the parameter file is accessed and the parameters are retrieved from the file. The data file is also accessed at this time so that the coordinate variable values may be loaded by the program. If an error occurs while trying to access or read the parameter or data file, a message will be displayed indicating the problem, and any key may be pressed to return to the Main menu. If parameters and data are successfully loaded a message will be displayed, and pressing any key will cause the Krige Options screen and menu to be displayed.

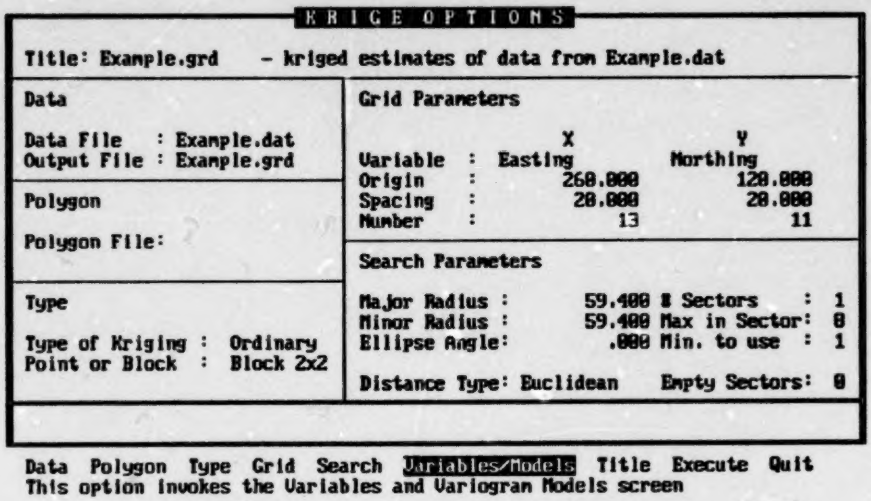
**Options/Execute**

The Options/Execute option provides access to the Krige Options screen and menu. See the section below for more information.

**Save Parameters**

The Save Parameters options provides a means of storing program parameter values in a parameter file for later use. When this option is selected a prompt is issued for the Output Parameter File name. A default name is constructed with a "kpf" file extension as described above for the Read Parameters option. If the named file already resides on disk, a Yes/No prompt provides a means of overwriting the old file or exiting the option. If an error occurs while trying to create or write to the Output Parameter File a message will be displayed, and pressing any key causes re-activation of the Main menu. If the parameters are successfully stored in the file, a message is displayed and a keystroke re-activates the Main menu.

## 12.5 THE OPTIONS MENU



```
                         KRIGE OPTIONS
Title: Example.grd    - kriged estimates of data from Example.dat

Data                          Grid Parameters

Data File   : Example.dat                    X              Y
Output File : Example.grd     Variable  :  Easting        Northing
                              Origin    :      260.000        120.000
Polygon                       Spacing   :       20.000         20.000
                              Number    :           13             11
Polygon File:
                              Search Parameters

Type                          Major Radius :     59.400 # Sectors    :  1
                              Minor Radius :     59.400 Max in Sector:  0
Type of Kriging :  Ordinary   Ellipse Angle:       .000 Min. to use  :  1
Point or Block  :  Block 2x2
                              Distance Type: Euclidean  Empty Sectors:  0

Data  Polygon  Type  Grid  Search  Variables/Models  Title  Execute  Quit
This option invokes the Variables and Variogram Models screen
```

Figure 12-2 Krige Options Screen

The Options screen and menu (Figure 12-2) has the options to specify the parameters to be used for kriging, and to initiate the kriging process. The menu line appears as follows:

```
Data Polygon Type Grid Search Variables/Models Title Execute Quit
```

**Data**

The Data option is used to specify the name of the Geo-EAS data file whose values will be used for kriging, and the name of the Geo-EAS output file of gridded estimates. The screen fields accessed through the Data option are:

Data File - A 14 character alphanumeric field in which the name of the input data file is entered. The most recently used Geo-EAS data file name is the default. Once the name is given the program reads the variable names from the file into several toggle fields used for selecting the coordinate variables and the variables to krige. If the data file cannot be located or an error occurs while accessing the file an error message is generated. If the variable names are loaded successfully the Krige Options menu will be reactivated.

Output File - A 14 character alpha-numeric field for entering the name of the output file of gridded estimates. A default name is constructed which consists of the input data file name with a ".grd" extension (signifying gridded data). If the specified file already resides on disk, a Yes/No prompt provides the alternative of overwriting the file or exiting the option.

**Polygon**

The Polygon option is used to specify the name of a file containing polygonal boundaries which limit the area in which estimates are produced. This file should contain one or more lists of polygon vertices which form closed polygons. Each vertex list is preceded by a flag which indicates if it is to be treated as an inclusive or exclusive polygon. No estimates may be kriged within an exclusive polygon boundary, and none may be produced outside an inclusive boundary. The polygon file is read when the Execute option is used to initiate kriging. If an error occurs while reading the Polygon file, a message will be generated, the file will be ignored and an attempt to krige all grid cells will be made. See the appendices for a detailed description of the polygon file format.

**Type**

The Type option is used to select the type of kriging to use and whether to krige point or block estimates. The screen fields accessed from this option are:

Type of Kriging - A toggle field containing the choices "Ordinary", and "Simple" which is used to specify the type of kriging to perform. If "Ordinary" is chosen, ordinary kriging will be performed. If "Simple" kriging is chosen, simple kriging is performed and a value must be specified for the Global Mean when entering the variogram model parameters on the Variables/Models screen.

Point or Block - A toggle field containing the choices "Point", "Block 2x2", "Block 3x3", and "Block 4x4", which is used to indicate point or block kriging. If one of the "Block NxN" choices is selected, block estimates will be produced. The "N" refers to the number of discretization points used to approximate the area of the block. Large "N" values give somewhat better approximations of the blocks at the expense of increased computing time. The choice of point or block also determines the meaning of the Grid Origin parameters. If block kriging is chosen these parameters refer to the center of the lower left-hand block in the grid.

**Grid**

The Grid option is used to specify the variables to use as coordinate values, the origin of the grid, the size of grid cells, and the number of cells in the X and Y directions. These are specified with four screen fields for each of the two directions. The screen fields for the X and Y directions are:

Variable - Two toggle fields containing the variables names from the specified input data file which are used to specify the variables to be used as the sample coordinate values when kriging. The default values for the X and Y variables are the first and second variables in the data file. Once the variables have been chosen the coordinate values are retrieved from the data file. If an error occurs during the retrieval of data, a message is displayed, and pressing any key will re-activate the Krige Options menu, but it is assumed that the file is corrupted and cannot be used. A new data file name must be specified. If no grid parameter values have been previously specified, default values for the Origin, Cell Size, and Number of Cells parameters are computed.

Origin - Two numeric fields used for entering the X and Y coordinate values for the origin of the kriging grid. If block kriging (the default) were selected the origin is taken as the center of the lower left-hand grid block.

Cell Size - Two numeric fields for specifying the grid cell size. For point kriging these values will indicate the distance between points in the grid. For block kriging these parameters will indicate the size of the blocks to be kriged (the distance between block centers in each direction). Both values must be non-zero, and non-negative.

# Cells - Two numeric fields for selecting the number of points or blocks to be produced in each of the two directions. These values must be non-zero, non-negative, and may not exceed 100.

### Search

The Search option provides a means of controlling the neighborhood search used during kriging. Parameters may be specified to define an elliptical search area. Constraints may be placed upon the number of sectors and the number of samples to be retained in each sector of the search area, and the type of distance measure to use when eliminating neighbors from a search sector. The screen fields accessed from this option are:

R Major - A numeric field for indicating the length of the major radius (half the length of the longest axis) of the search ellipse.

R Minor - A numeric field for indicating the length of the minor (shortest) radius of the search ellipse. This value must be less than or equal to R Major, non-zero, and non-negative. The default value is the value given for R Major. If R Major is equal to R Minor, the search area will be a circle.

Angle - A numeric field for indicating the orientation of the search ellipse. It is given in trigonometric degrees in the range from zero up to (but not including) 180, and indicates the angle between the longest axis of the ellipse (specified by R Major) and the sample coordinate X axis. If R Minor is equal to R Major, a circle search is used and the Angle parameter is ignored.

Distance Type - A two valued toggle field for selecting the type of distance measure to use when eliminating neighbors. The choices available are "Euclidean" (the default), and "Variogram". Neighboring samples are eliminated from consideration when the Max Pts/Sector (Maximum points per sector) criterion is exceeded in a given sector. If this should occur, only the "closest" neighbors are kept. If the "Euclidean" distance type is chosen, neighbors are eliminated based upon the euclidean distance from the point to be estimated ellipse center. If "Variogram" distance is chosen, the variogram function value (as specified by the Model parameters) for the computed distance is used as the criterion for elimination of neighbors.

Num. Sectors - A toggle field for selecting how many sectors in which to divide the search ellipse. The choices available are "1" (the default), "4", and "8". The combination of the Number of Sectors, and the Max Points per Sector parameters indicate the maximum number of samples to be used for kriging. This parameter also serves to indicate the number of groups to use for classification of neighbors. The search ellipse is divided into the chosen number of equally-sized sectors. If a sample is found to be within the search ellipse, its' sector number is stored. These sector numbers and sample distances are used for elimination of samples which exceed the Max Pts/Sector value.

**Max. Pts/Sector** - A toggle field for selecting the maximum number of points which a sector may contain. The choices range from "1" to a maximum which depends on the number of sectors chosen. If one sector is specified, up to 24 points neighbors may be used. If four or eight sectors are selected, the choices are constrained such that a maximum of 64 neighbors may be retained. If the number of neighbors in a sector exceeds the specified value, the "farthest" samples (as determined by Distance Type) are eliminated from consideration.

**Min Pts. to Use** - A toggle field for selecting the minimum number of neighboring samples to use for kriging. The default value or this parameter is "1". If fewer than the specified number of samples are found then kriging is not performed and a missing value is generated for the estimate and kriging standard deviation.

**Empty Sectors** - A toggle field for selecting the maximum number of consecutive sectors with no neighbors. The choices available are determined by the Number of Sectors parameter. If one sector is chosen, then this input is ignored. If more than the specified number of consecutive sectors are empty, no value is kriged and missing values are generated in place of an estimate and kriging standard deviation.

### Variables/Models

The Variables/Models option is used to access the Variables/ Models screen and menu. This screen and menu are used for selecting the variables to krige and the variogram model to use for each variable. Up to ten variables may be selected for kriging. At least one must be specified prior to selection of the Execute option. The Variables/Models screen and menu is discussed below.

### Title

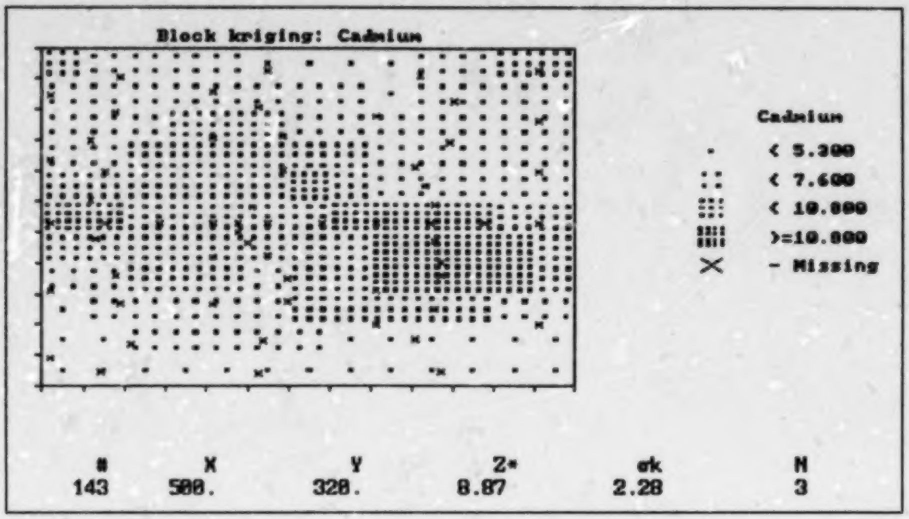
The Title option is used to indicate the descriptive title to store in the output file of gridded estimates. It provides access to a 60 character alphanumeric field for storing the title. A default title is constructed from the data file name and the output file name. Any valid alphanumeric character string may be entered.

### Execute

The Execute option is used to initiate kriging. All parameters must be specified before kriging may begin. Several "Debug Options" (described below) are enabled or disabled with the <caps-lock>, the <num-lock>, and the <scroll-lock> keys. These keys are used to toggle the debug displays on or off. It is important to disable all three Debug Options prior to using the Execute option, or intermediate results screens will be generated and kriging will proceed more slowly.

If your personal computer is equipped with the proper graphics hardware, a graphics display (shown in Figure 12-3) is generated when the Execute option is selected. In this display the original sample locations are represented by the "x" symbol. As each point is kriged, the estimates and associated results are displayed at the bottom of the screen (except in Hercules-equipped systems) and the point or block estimates are plotted with a symbol which indicates the quartile of the estimate. On EGA equipped computer systems, these symbols and the sample values are also color coded. A legend is displayed at the right of the screen showing the symbols and corresponding quartile cutoff values. If your computer system has no graphics capability, no graph is displayed, and the results are displayed at the bottom of the Krige Options screen.

During the kriging process the debug displays (described below) may be activated or de-activated to view intermediate kriging results. Once all grid cells have been kriged, a tone signals that the kriging has been completed. Pressing <q> will cause the Krige Options screen and menu to be displayed and a message will be generated to indicate that the results were successfully written to the output file. If an error occurs while attempting to write to the file, kriging will be halted and an error message will be displayed.



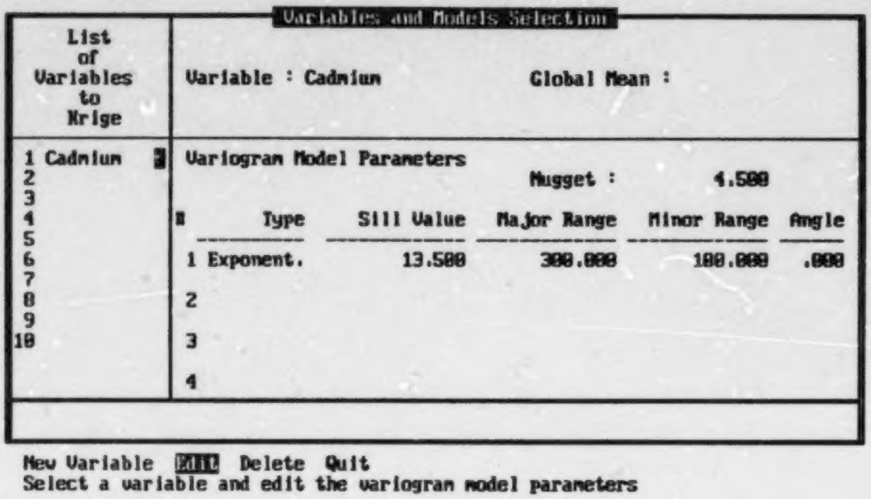
```
  #      X          Y          Z*         σk          N
 143    500.       320.       8.87       2.28         3
```

Figure 12-3    Kriging Display

### How to Cancel Kriging

At any time during the kriging process, kriging may be canceled by pressing the <ctrl> and <alt> keys, the <ctrl> and <shift> keys, or the <left shft> and <right shft> keys simultaneously and holding them down until the next point or block has been kriged. If this is done a message is displayed indicating that kriging has been terminated. This is useful when the debug screens reveal a problem with the search or variogram parameters and you wish to change them and re-start. Note that in this situation the output file will not contain a completed grid of estimates and probably cannot be used by the program Conrec. It is important to remember that the "terminate kriging" keys will not work when any of the three debug display keys is active.

## 12.6 THE VARIABLES/MODELS MENU



```
                           Variables and Models Selection
    List
     of
  Variables     Variable : Cadmium               Global Mean :
     to
   Krige

 1 Cadmium    Variogram Model Parameters
 2                                         Nugget :          4.500
 3
 4            #     Type      Sill Value  Major Range  Minor Range  Angle
 5               ----------  ----------  -----------  -----------  -----
 6             1 Exponent.      13.500      300.000      100.000    .000
 7
 8             2
 9
10             3

               4

New Variable  Edit  Delete  Quit
Select a variable and edit the variogram model parameters
```

Figure 12-4 Krige Variables/Models Screen

The Variables/Models screen and menu (Figure 12-4) is provided for selection of the variables to krige and to specify the variogram model for each of the selected variables. The Variables/Models screen is divided into three areas. The area on the left of the screen is used to display the list of variables selected for kriging, called the Kriging List. This list is used as a menu from which to select a variable when deleting or editing a variable/model specification. On the right, the top area is for selecting new variables to add to the Kriging List and the bottom area is for entering variogram model parameters. The Variables/Models menu provides options to add or delete a variable and model to the Kriging List, and to edit a set of variogram model parameters. The menu line appears as follows:

```
New Variable  Edit  Delete  Quit
```

**New Variable**

The New Variable option is used to select a variable to add to the Kriging List. A toggle field is displayed in the top portion of the screen which contains the variable names from the input file. The default value for this field is the third variable name in the file. Once this selection is made the variable name is added to the Kriging List and the variogram model parameters (described below) must be entered.

> *** Note *** it is possible to krige the same variable more than once; the output file will then contain duplicate variable names.

### Edit

The Edit option allows you to edit the specified variogram model for the specified variable. When this option is selected the Kriging List menu is activated. A cursor may be moved to the appropriate member of the list with the <up> or <down> keys and selected for editing with <enter>. Once the variable has been specified the parameters will be loaded onto the screen and the Variogram Model Parameters area will be activated. In this screen area fields are provided for a nugget effect value and up to 4 additive variogram structures. Each structure is specified with a structure type, a sill value, and an ellipse of influence. If simple kriging is chosen an additional field is provided for entering the Global Mean. Each of the four structures has five associated screen fields. Selecting the Model option will cause a cursor bar to appear in the upper left corner of the models area. The arrow keys may be used to move the cursor bar to fields in the Model area. To exit the Model area, move the cursor bar out of the top or off to the left of the area, using the <left>, or <up> keys. If any errors are made when entering variogram model parameters an error message will be displayed and the cursor bar will be placed at the problem field. The screen fields accessed from this option are:

Nugget - A numeric field for entering the nugget value for the variogram model. Only values greater than or equal to zero may be entered. The default value is zero.

Global Mean - A numeric field for specifying the global mean for simple kriging. If ordinary kriging is chosen this field is disabled and cannot be accessed. The default value for the global mean is zero.

The following five fields are present for each of the four additive variogram structures:

Type - A toggle field for indicating the type of the structure. The toggle field choices for type are "      " (none), "Spherical", "Gaussian", "Exponential", "Linear". The default type for all four structures is "none". If a structure is entered and the type is subsequently changed to "none" the structure will be deleted from the variogram model. The order of the variogram structures on the screen is unimportant; neither do they need to be in a contiguous order on the screen.

Sill - A numeric field for entering the sill value for a variogram structure. A non-zero, non-negative value is required here. If a linear variogram type is selected the sill value is used together with the variogram ellipse ranges to determine a slope for a given direction. In a linear variogram structure the sill must be chosen so that the corresponding range parameter values will result in the desired slope.

Major Range - A numeric value for entering the longest range of influence of the variogram structure. The Major Range must be non-zero, and non-negative. This may be thought of as similar to the R Major parameter described in the Search option above. In fact, the variogram ellipse of influence is defined exactly as the search ellipse: with two ranges (radii) and an angle. Note however that the two ellipses have fundamentally different purposes, although the parameters which describe them are the same

Minor Range - A numeric field for indicating the length of the minor (shorter) range of the variogram ellipse. This value must be non-zero, non-negative, and less than or equal to the Major Range. The default value is the Major Range value. If the two ranges are equal, an isotropic variogram structure is defined. If they are not equal, the two ranges are used to determine the ratio of anisotropy.

Ellipse Angle - A numeric field for indicating the orientation of the ellipse for the variogram structure. It is given in trigonometric degrees in the range from zero up to (but not including) 180, and indicates the angle between the longest axis of the ellipse (specified by the Major Range) and the sample coordinate X axis. If the two ranges are equal (isotropic structure) then the angle is ignored.

**Delete**

The Delete option is used to delete a variable and model from the kriging list. When this option is selected, the Kriging List menu will be activated, and the variable to delete may be selected as described in the Edit option. Once this selection is made, a Yes/No prompt provides the alternative of canceling the deletion. If <y> is chosen, the variable and model will be deleted and the Kriging List and screen will be regenerated. This option is disabled when the Kriging List is empty.

## 12.7 THE DEBUG DISPLAYS

The debug displays are provided as a means of viewing intermediate kriging results during the kriging process. Since such displays slow the kriging process, the displays may be activated, or de-activated at any time during kriging. If the <num-lock>, <caps-lock>, or <scroll-lock> keys are activated during kriging, the corresponding displays will be generated on the screen. To continue to the next display, the <q> key is pressed. To disable the generation of these displays, the corresponding keys should be de-activated. On an IBM AT-style keyboard, these three keys are accompanied by status lights which indicate that the key is "on", or "off". The following is an explanation of each display, and the key which activates it:

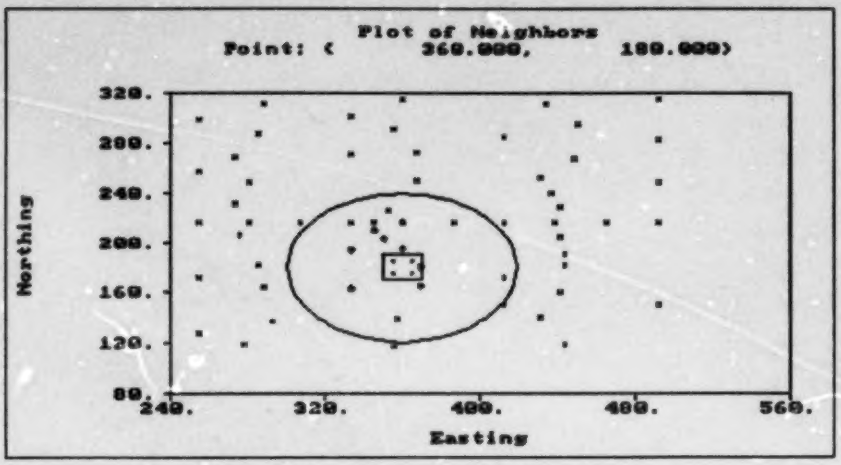
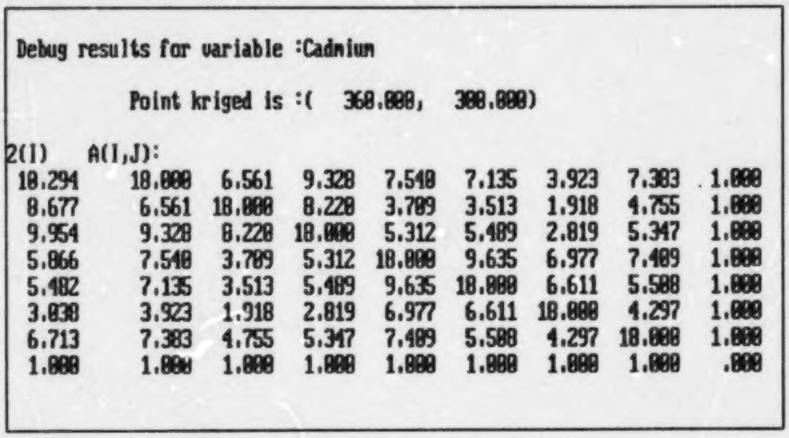


Figure 12-5    Krige Debug: Search Area Display

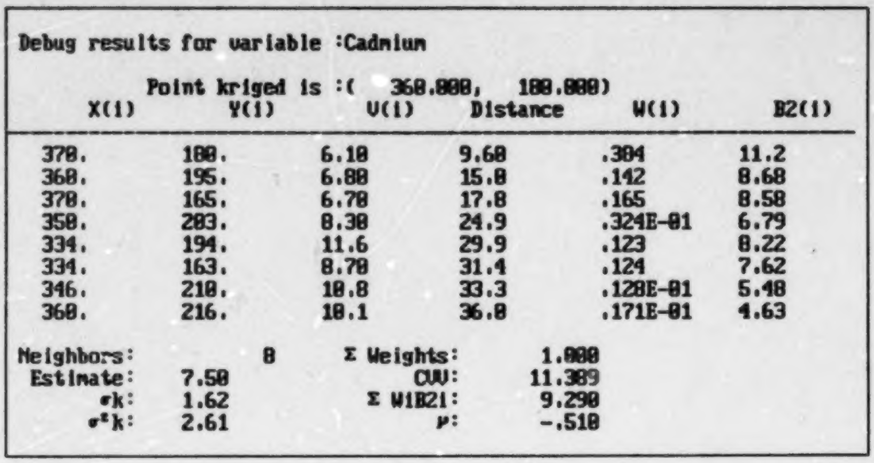
**<caps lock>** - This activates the Search Area display, shown in Figure 12-5. For each estimate, the search ellipse is displayed along with all sample locations in the sampled area. The neighbors which were chosen for the estimate are marked. The coordinates of the estimated point (center of the search ellipse) is displayed at the top of the screen. If more than one sector was chosen, the sector boundaries will be plotted. This display may be used to check if the search ellipse is of the proper size and orientation, and that the desired number of samples are used as neighbors. On a non-graphics system this display is a text display showing the list of neighbors, the sample locations, and the sector number for each neighbor.



```
Debug results for variable :Cadmium

          Point kriged is :(   360.000,   300.000)

Z(I)    A(I,J):
 10.294     10.000   6.561   9.328   7.540   7.135   3.923   7.383  1.000
  8.677      6.561  10.000   8.220   3.709   3.513   1.918   4.755  1.000
  9.954      9.328   8.220  10.000   5.312   5.409   2.819   5.347  1.000
  5.066      7.540   3.709   5.312  10.000   9.635   6.977   7.409  1.000
  5.402      7.135   3.513   5.409   9.635  10.000   6.611   5.508  1.000
  3.030      3.923   1.918   2.819   6.977   6.611  10.000   4.297  1.000
  6.713      7.383   4.755   5.347   7.409   5.508   4.297  10.000  1.000
  1.000      1.000   1.000   1.000   1.000   1.000   1.000   1.000   .000
```

Figure 12-6    Krige Debug:  System of Equations Display

**<scroll lock>** - This key activates a display (Figure 12-6) which shows the system of equations used to produce the estimate. A one-dimensional array of values on the left of the screen shows the covariances between the estimate location and the neighbors, and the matrix of values in the remaining portion of the screen shows the covariances between neighboring samples. If the number of neighbors used in the system of equations is more than eight, each row of the matrix will "wrap-around" to the next line and produce an undesirable results. This display allows you to see the actual covariance values used for kriging, for comparison with other programs or for verification of results.



```
Debug results for variable :Cadmium

          Point kriged is :(   360.000,   180.000)
     X(i)          Y(i)          V(i)     Distance       W(i)         B2(i)

   370.         180.          6.10        9.60        .304          11.2
   360.         195.          6.80        15.0        .142          8.60
   370.         165.          6.70        17.0        .165          8.50
   350.         203.          8.30        24.9        .324E-01      6.79
   334.         194.          11.6        29.9        .123          8.22
   334.         163.          8.70        31.4        .124          7.62
   346.         210.          10.8        33.3        .120E-01      5.40
   360.         216.          10.1        36.0        .171E-01      4.63

Neighbors:             8      Σ Weights:        1.000
 Estimate:    7.50                  CVV:       11.389
       σk:    1.62             Σ WiB2i:         9.290
      σ²k:    2.61                    μ:        -.510
```

Figure 12-7    Krige Debug:  Kriging Weights Display

**<num lock>** - This key activates the Kriging Weights display, shown in Figure 12-7. This display provides information about the neighboring samples used for kriging each estimate. This includes the coordinate values, the sample values, the distances from the estimated point, and the kriging weights assigned to each neighbor. Also displayed are the kriging estimate, the kriging standard deviation, and several related statistics, including the sum of the kriging weights, the kriging variance, and the Lagrange parameter value.

# SECTION 13

# POSTPLOT

## 13.1 WHAT POSTPLOT DOES

Postplot produces a plot of (2D) sample locations and values for a variable in a Geo-EAS data file. Sample locations may be marked with a symbol, value, or both. The format for the value to be plotted may be specified by setting a scaling factor and the number of decimal places to be used in the plotted value. Options allow control of axes parameters, and titles. A file called a "metacode" file is created for redisplay or to produce a hardcopy.

**Note:** Postplot attempts to produce "true-scale" graphs on the screen, but for some data configurations, an internal NCAR routine overrides true scaling and produces a somewhat distorted graph.

## 13.2 DATA LIMITS

Postplot requires that the input data file contain at least 3 but not more than 48 variables. These should consist of an X and Y coordinate and a third variable which will be posted. The data file may contain up to 1000 samples. If the data file contains more than 1000 samples, only 1000 will be used by Postplot.

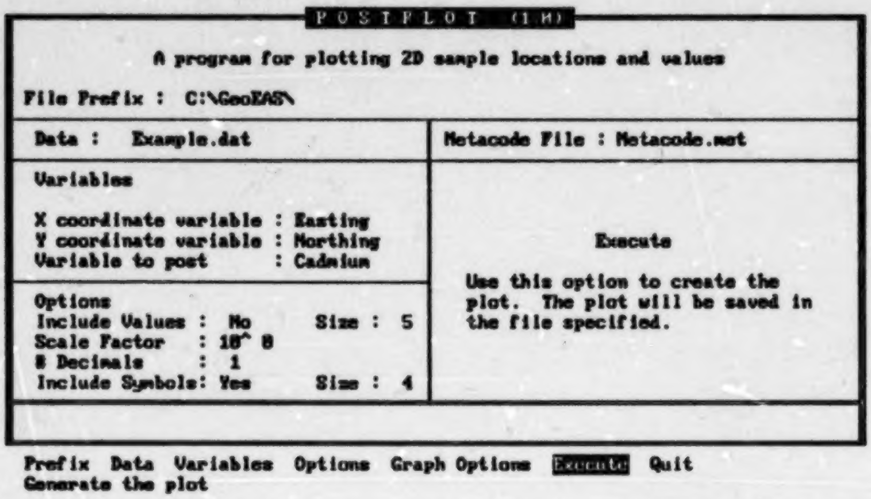
## 13.3 THE MENU HIERARCHY

```
Postplot --- Prefix
           | Data
           | Variables
           | Options
           | Graph Options --- Axis Parameters
           |                 | Tick Parameters
           |                 | Graph Limits
           |                 | Titles/Labels
           |                 | Reset
           |                 \ Quit
           | Execute
           \ Quit
```

## 13.4 THE MAIN MENU

The Main screen and menu, shown in Figure 13-1, has the options to allow specification of the data and metacode file names, the selection of the variables to be used and the options for displaying the posted variable. The menu line appears as follows:

```
Prefix  Data  Variables  Options  Graph Options  Execute  Quit
```



```
A program for plotting 2D sample locations and values

File Prefix :  C:\GeoEAS\

Data :   Example.dat                  Metacode File : Metacode.met

Variables

X coordinate variable : Easting
Y coordinate variable : Northing
Variable to post      : Cadmium

Options                                          Execute
Include Values :  No       Size :  5
Scale Factor   : 10^ 0                 Use this option to create the
# Decimals     :  1                    plot.  The plot will be saved in
Include Symbols: Yes       Size :  4   the file specified.

Generate the plot
```

Figure 13-1    Postplot Main Screen

**Prefix**

The Prefix option is used to enter the prefix for file names.

**Data**

The Data option is used to enter the name of a Geo-Eas data file.

**Variables**

The Variables option allows the selection of variables that are to be used as the X and Y coordinate values, and the sample values to post. The choices available are the variable names as specified in the data file. The screen fields accessed from this option are:

X Coordinate Variable - A toggle field for selecting the variable name whose values will be used as the X coordinates. The default X variable is the first variable in the data file.

Y Coordinate Variable - A toggle field for selecting the variable whose values will be used as the Y coordinates. The default Y variable is the second variable in the data file.

Variable to post - A toggle field for selecting the variable whose values will be posted on the plot. The default variable to post is the third variable in the data file.

**Options**

The Options option allows the specification of how the sample locations are to be marked on the graph. The screen fields accessed from this option are:

Include Values - A two-valued (Yes/No) toggle field to enable or disable the labeling of samples with their numeric values. The choices available are "Yes" - plot values, "No" - do not plot values. The default value is "No".

Size - Two toggle fields for selecting the character size to use when plotting the values or symbols. The choices available are "0" to "10", where "0" is the smallest and "10" is the largest character size. The default size for plotting values is "5", and the default for plotting symbols is "4". These choices work well on the screen, however a smaller size might be more suitable for output to a plotter.

Scale Factor - A toggle field for selecting the scaling factor to apply to the values to be plotted. The choices available range from "10^-4" to "10^4". The scaling factor shifts the decimal place left or right in the plotted value. For example a scale factor of 10^4 applied to a value of 7.208 would result in the value 72080 being plotted. If the Include Values field is set to "No", this choice is ignored. If the default of "10^0 "is used the decimal place will not be shifted.

# Decimals - A toggle field for selecting the number of digits to display. The choices available range from "0" to "3". For example, selecting "2" with a value of 72.208 would result in the value 72.21 (round up does occur) being plotted. The default is "1" (one digit to the right of the decimal place).

Include Symbols - A two-valued (Yes/No) toggle field to enable or disable the plotting of symbols at the sample locations. The choices available are "Yes" - plot symbols, "No" - do not plot symbols. If the value is "Yes" (the default) four different symbols in four different colors will be plotted to represent the values within their quartiles. A legend is also plotted to show the quartile cutoff values, the symbols, and their corresponding colors.

**Graph Options**

The Graph Options option provides access to the Graph Options screen and menu, described below.

**Execute**

When the Execute option is selected, you will be prompted for a metacode file name. The metacode file is then created and the graph is displayed. The metacode file name entered may be up to 14 characters. The default value is "Metacode.met". If the default value is not used and the file specified already exists, a Yes/No prompt for whether or not to overwrite the file is displayed. This file contains the metacode instructions produced by the program. It will be saved for future viewing. A hard copy of the graph can be obtained by using the program Hpplot and an HPGL compatible plotter. After the graph has been displayed, type <q> to clear the screen and return to the Main menu. An example post plot is shown in Figure 13-2.

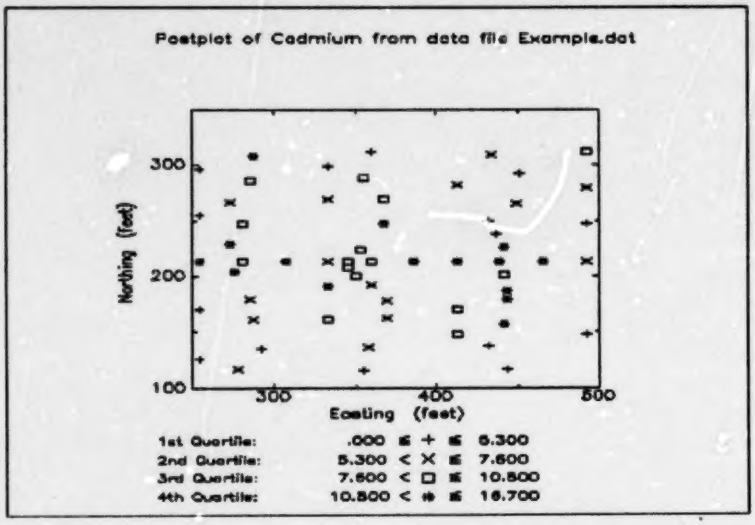
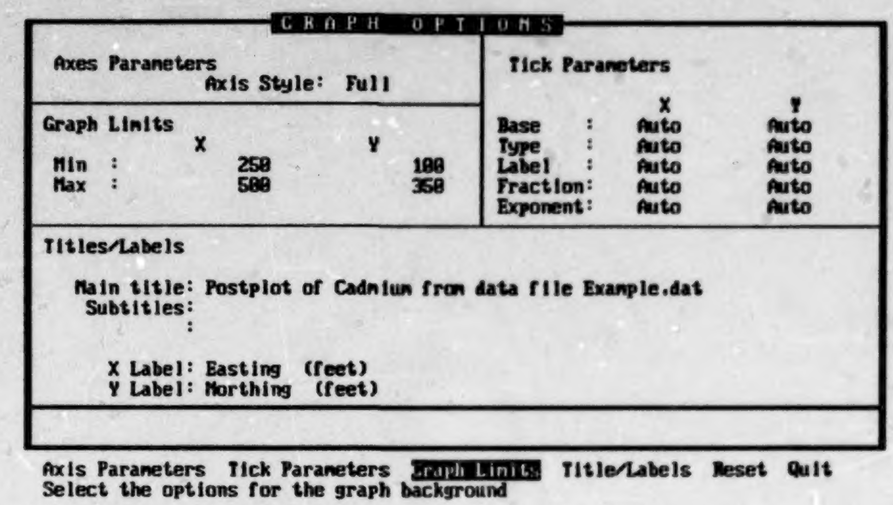


Figure 13-2 Example Post Plot



```
                          GRAPH OPTIONS
 Axes Parameters                          Tick Parameters
               Axis Style: Full
                                                    X          Y
Graph Limits                             Base     : Auto       Auto
                X              Y         Type     : Auto       Auto
 Min  :          250            100      Label    : Auto       Auto
 Max  :          500            350      Fraction : Auto       Auto
                                         Exponent : Auto       Auto
Titles/Labels

   Main title: Postplot of Cadmium from data file Example.dat
    Subtitles:
             :

      X Label: Easting  (feet)
      Y Label: Northing  (feet)

Axis Parameters  Tick Parameters  Graph Limits  Title/Labels  Reset  Quit
Select the options for the graph background
```

Figure 13-3 Postplot Graph Options Screen

The Graph Options screen and menu, displayed in Figure 13-3, provides control over the "graph background" parameters. These parameters are used to specify the axis style, the graph limits, titles and axis labels, and the tickmark labeling and spacing. The menu line appears as follows:

```
Axis Parameters  Tick Parameters  Graph Limits  Title/Labels  Reset  Quit
```

### Axis Parameters

The Axis Parameters option allows the selection of the type of axis style for the background of the plot. The screen field accessed from this option is a toggle field. Choices available are "Half" (left and bottom axes only), "Full" (left, right, top, and bottom axes) and "Grid" (the same as "Full", but the major tickmarks extend across to the opposite axis). The default axis style is "Full".

### Tick Parameters

The Tick Parameters option allows specification of the nature of the numeric tickmark labels to be placed along each axis. This is accomplished with a set of closely inter-related parameters which control the format of the labels. The default values are initially set to "Auto", and provide adequate labels for most data. With the appropriate selection of parameter values, however, many useful labels may be constructed, including fractions and superscripted powers of ten. An excerpt from the NCAR documentation on tickmark parameters is included in the appendices. Certain incompatible combinations of parameter choices will result in no labels being plotted or error messages generated by the NCAR Autograph utility. These errors will cause the program to terminate. To recover, restart and change the parameters. A menu option is provided to "reset" these parameters to "Auto", so that the default values may be used. The screen fields accessed from this option are:

Base - Two numeric fields used for the computation of major tick marks along the X and Y axes. The user may accept the default value of "Auto" which allows the system to select the appropriate value, or enter a value appropriate for the variable selected.

Type - Two toggle fields for selecting a formula for computing (using Base, entered above) the spacing of the tick marks along the X and Y axes. Choices available are:

Auto (System will select appropriate computation)
None (No tick marks on axis)
- Base * k
- Base * 10^k
- Base^k

Note: "k" is an arbitrary integer computed by the program. The default value is "Auto" for both axes.

Label - Two toggle fields for selecting the format of numeric tickmark labels along the X and Y axes. Choices available are:

Auto - System will select appropriate format
None - No tick marks on axis
Scien. - Scientific notation
Expon. - Exponential notation
No-Exp. - Non-exponential notation

Fraction - Two numeric fields for entering the number of significant digits to display in the numeric axis labels.

Exponent - Two numeric fields for entering the value of the exponent in the numeric axis labels.

Table 13-1 shows examples of the types of numeric tick mark labels that can be produced, using combinations of choices for the Base, Type, Label, Fraction, and Exponent parameters. The labels were produced using the Example.dat data file with Easting as the X variable and Northing as the Y variable. Remember that certain combinations of parameter values are incompatible, and will result in unexpected results, or a lack of tickmark labeling. The Reset option may be used to set parameter values back to their defaults if this occurs.

| Base | Type | Label | Fraction | Exponent | Results |
|---|---|---|---|---|---|
| Auto | ·Base*k | Scien. | Auto | Auto | $2.50 \times 10^2$ |
| Auto | ·Base*10^k | Expon. | Auto | Auto | $10^2$ |
| 2. | ·Base*10^k | Scien. | 1. | Auto | $.2 \times 10^3$ |
| 2. | ·Base^k | No-Exp. | -1. | Auto | 64 |
| Auto | ·Base^k | Expon. | 1. | 3. | $.2 \times 10^3$ |
| 3.6 | ·Base*10^k | No-Exp. | 1. | Auto | 30 |
| Auto | ·Base^k | Scien. | 2. | 1. | $100.01 \times 10^0$ |
| 5. | ·Base^k | Expon. | 3. | Auto | $5.0^2$ |

Table 13-1 Numeric Tickmark Label Examples

**Graph Limits**

The Graph Limits option allows you to enter values that specify the coordinate limits for the X and Y axes. Certain combinations of the Tick Parameters will cause these values to be overridden by the program. The screen fields accessed from this option are:

Min - Two numeric fields for entering the minimum coordinate value to be used on the X and Y axes. The default values displayed are determined from the variables selected as the X and Y coordinate values.

Max - Two numeric fields for entering the maximum coordinate value to be used on the X and Y axes. The default values displayed are determined from the variables selected as the X and Y coordinate values.

**Titles/Labels**

The Titles/Labels option allows you to enter the title and labels for the graph. The Hershy character sets of 33 fonts are used for plotting alphanumeric labels. Also, certain "special characters" may be embedded in the title or label which control selection of alternate fonts or other aspects of the plotted text. These special characters are not plotted, but are interpreted as commands by the metacode translator software. The appendices contain information on font selection codes. The screen fields accessed from this menu option are:

Main title - An alphanumeric field which may contain up to 60 characters for the main title of the graph. The default title contains the variable name selected as the post variable and the name of the data file.

Subtitles - Two alphanumeric fields which may contain up to 60 characters each for the subtitles on the graph. The subtitles appear below the main title.

X Label - An alphanumeric field which may contain up to 60 characters for the X axis label. The default label is composed of the X variable name followed by its units in parentheses.

Y Label - An alphanumeric field which may contain up to 60 characters, for the label on the Y axis. The default label is composed of the Y variable name followed by its units in parentheses.

**Reset**

The Reset option allows the user to reset the graph options parameters to their default values.

# SECTION 14

# XYGRAPH

## 14.1 WHAT XYGRAPH DOES

Xygraph produces line and/or scatter plots for up to six variables in a Geo-EAS data file. Plots of up to six dependent variables with one independent variable can be obtained. Up to six colors, symbols, and line types may be used to identify the data. Options allow a regression line to be calculated and axes parameters and graph labeling to be controlled. A file called a "metacode" file is created for redisplay or to produce a hardcopy.

## 14.2 DATA LIMITS

Xygraph requires that the input data file contain at least two but not more than 48 variables. The data file may contain up to 500 samples. If the data file contains more than 500 samples, only 500 will be used by Xygraph.

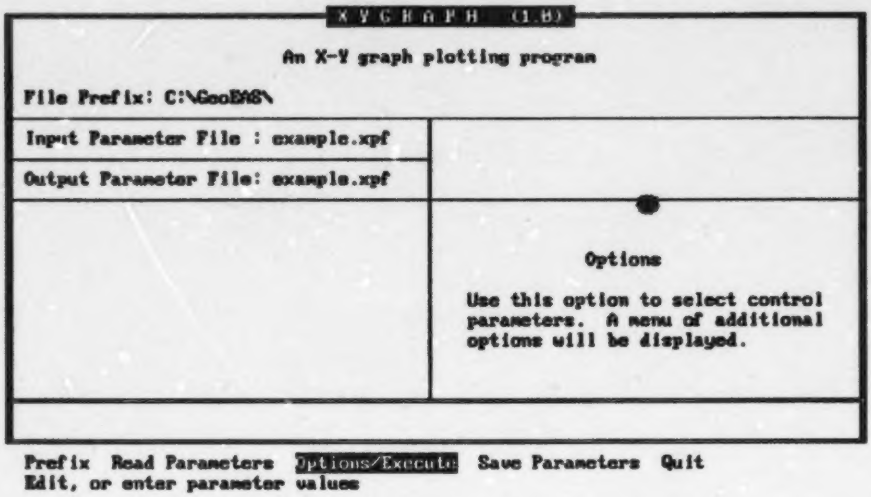
## 14.3 THE MENU HIERARCHY

```
Xygraph --- Prefix
          | Read Parameters
          | Options/Execute --- Data
          |                   | Variables
          |                   | Symbol/Line
          |                   | Regression
          |                   | Legend
          |                   | Graph Options - Axis Parameters
          |                   |               | Tick Parameters
          |                   |               | Graph Limits
          |                   |               | Titles/Labels
          |                   |               | Reset
          |                   |               \ Quit
          |                   | Execute
          |                   \ Quit
          | Save Parameters
          \ Quit
```

## 14.4 THE MAIN MENU

The Main screen and menu ( Figure 14-1) has the options to allow specification of the input and output parameter file names. The menu line appears as follows:

```
Prefix  Read Parameters  Options/Execute  Save Parameters  Quit
```



```
                         XYGRAPH (1.0)
                  An X-Y graph plotting program
File Prefix: C:\GeoEAS\
Input Parameter File : example.xpf
Output Parameter File: example.xpf

                                         Options

                             Use this option to select control
                             parameters.  A menu of additional
                             options will be displayed.

Prefix  Read Parameters  Options/Execute  Save Parameters  Quit
Edit, or enter parameter values
```

Figure 14-1 Xygraph Main Screen

**Prefix**

The Prefix option is used to enter the prefix for file names.

**Read Parameters**

The Read Parameters option is used to enter the input parameter file name.

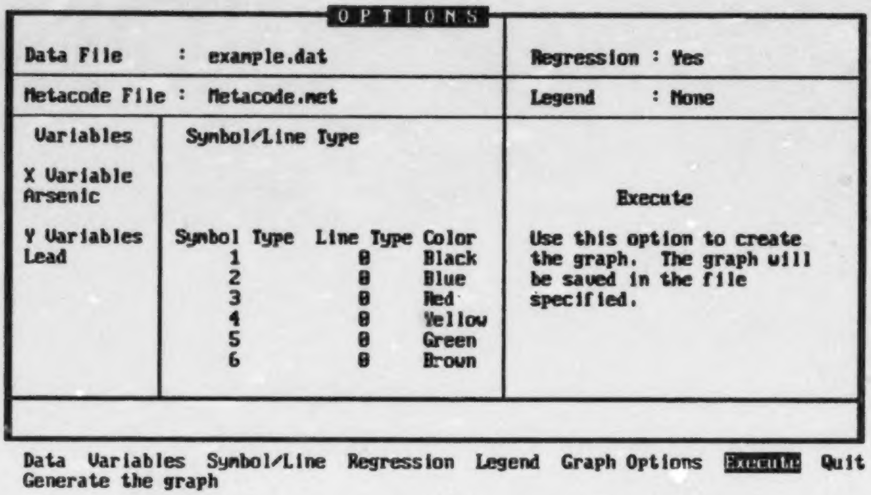
**Options/Execute**

The Options/Execute option provides access to the Options screen and menu. See the section on Options below for more information.

**Save Parameters**

The Save Parameters option is used to enter the name of the output parameter file. If the specified file already exists, a Yes/No prompt is provided to quit or proceed. The parameter file will contain the current parameter values. It will be saved for future use as an input parameter file.

## 14.5 THE OPTIONS MENU


OPTIONS
Data Variables Symbol/Line Regression Legend Graph Options Execute Quit

Data File : example.dat

Regression : Yes

Metacode File : Metacode.met

Legend : None

Variables

X Variable
Arsenic

Y Variables
Lead

Symbol/Line Type

| Symbol Type | Line Type | Color |
|---|---|---|
| 1 | 0 | Black |
| 2 | 0 | Blue |
| 3 | 0 | Red |
| 4 | 0 | Yellow |
| 5 | 0 | Green |
| 6 | 0 | Brown |

Execute

Use this option to create the graph. The graph will be saved in the file specified.

Generate the graph

Figure 14-2 Xygraph Options Screen

The Options screen and menu (Figure 14-2) has options to allow specification of the data and metacode file names, the selection of variables to be used, the options for displaying the variable, to compute a regression line, and the position of a graph legend. The menu line appears as follows:

Data Variables Symbol/Line Regression Legend Graph Options Execute Quit

**Data**

The Data option is used to enter the name of a Geo-EAS data file.

**Variables**

The Variables option allows the selection of variables that are to be used as the X and Y coordinate values. The choices available are the variable names as specified in the data file. The screen fields accessed from this option are:

X Variable - A toggle field used for selecting the variable name whose values will be used as the independent variable on the graph. The default X Variable is the first variable in the data file.

Y Variables - Six toggle fields used for selecting the variables whose values will be used as the dependent variables in the graph. The default Y Variable is the second variable in the data file.

**Symbol/Line**

The Symbol/Line option allows the specification symbols and/or lines and color to mark the data on the graph. The symbols and line types are displayed in Figure 14-3. The screen fields access from this option are:

Symbol Type - Six toggle fields for selecting the type of symbol to plot. There are six choices available ("0" to "6"). A value of "0" indicates that no symbols are to be plotted. The default Symbol Types for the six variables are "1" through "6".

Line Type - Six toggle fields for selecting the type of line to plot for each variable. There are six choices available ("0" through "6"). A value of "0" indicates that no line is to be plotted. The default Line Type for all six variables is "0".

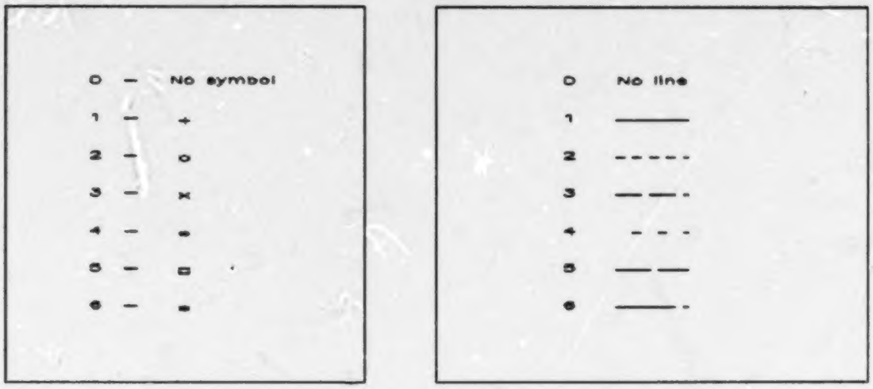


Figure 14-3 Xygraph Symbols and Line Types

Color - Six toggle fields for selecting the color to plot the symbol and/or line pattern. The choices available are "Black", "Blue", "Red", "Yellow", "Green", "Brown". The default color is unique for each variable.

**Regression**

The Regression option provides access to a two-valued (Yes/No) toggle field to enable or disable the calculation of linear regression. If the value is "Yes" linear regression is only calculated for the first Y variable. The regression line and the regression coefficients are plotted on the graph. The coefficients are the slope and intercept of the line represented by the equation Y = Slope * X + Intercept. The R Squared value (a measure of correlation) is also plotted. The default is "No".

**Legend**

The Legend option provides access to a toggle field that is used for selecting the position of the graph legend. The choices available are "None" (no graph legend), "Bottom" (at the bottom of the graph), and "Right" (at the upper right-hand corner of the graph). The default position is "None" (no legend).

**Graph Options**

The Graph Options option provides access to the Graph Options screen and menu, described below.

**Execute**

When the Execute option is selected you are prompted for a metacode file name. The metacode file is then created and the graph is displayed. The metacode file name entered may contain up to 14 characters. The default value is "METACODE.MET", or the name specified in the input parameter file. If the file name is not "METACODE.MET" and the file specified already exists, a Yes/No prompt provides the option to quit or proceed. The metacode file is saved on disk for future viewing. An example plot is displayed in Figure 14-4. A hard copy of the graph can be obtained by using the program Hpplot and an HPGL compatible plotter. After the graph has been displayed, type <q> to clear the screen and return to the Options menu.

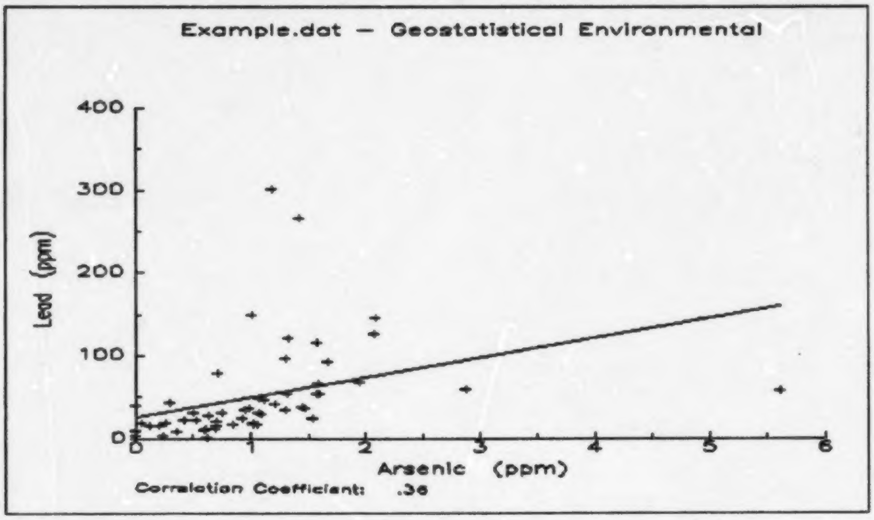
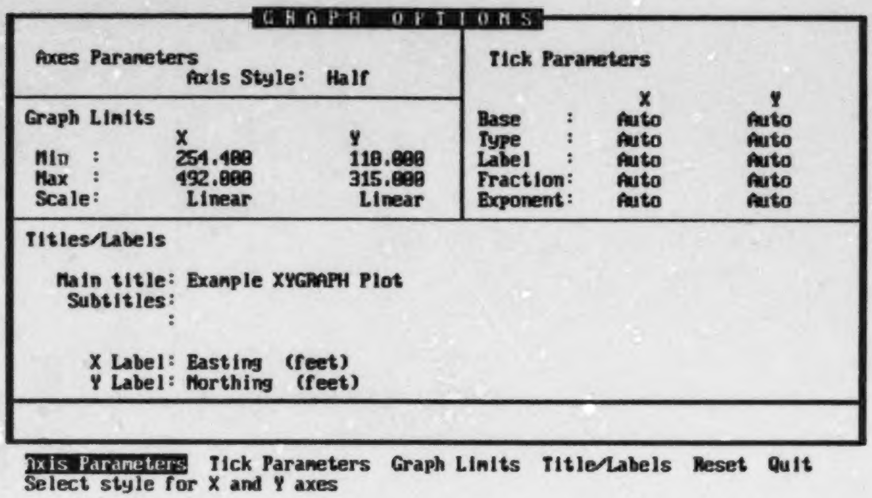


Figure 14-4 Example Xygraph Plot

## 14.6 THE GRAPH OPTIONS MENU



```
                           GRAPH OPTIONS
 Axes Parameters                          Tick Parameters
               Axis Style:  Half
                                                     X            Y
 Graph Limits                             Base     : Auto         Auto
               X              Y           Type     : Auto         Auto
 Min  :     254.400        110.000        Label    : Auto         Auto
 Max  :     492.000        315.000        Fraction : Auto         Auto
 Scale:     Linear         Linear         Exponent : Auto         Auto

 Titles/Labels

    Main title: Example XYGRAPH Plot
     Subtitles:
              :

       X Label: Easting  (feet)
       Y Label: Northing  (feet)

Axis Parameters  Tick Parameters  Graph Limits  Title/Labels  Reset  Quit
Select style for X and Y axes
```

Figure 14-5    Xygraph Graph Options Screen

The Graph Options screen and menu (shown in Figure 14-5) provides control over the "graph background" parameters. These include parameters which allow control of the axis style, the graph limits, titles and axis labels, and the numeric tickmark labeling and spacing. The menu line appears as follows:

Axis Parameters   Tick Parameters   Graph Limits   Title/Labels   Reset   Quit

### Axis Parameters

The Axis Parameters option allows the selection of the type of axis style for the plot. The screen field accessed from this option is a toggle field. The choices available are "Half" (left and bottom axes only) , "Full" ( left, right, top, and bottom axes) and "Grid" (the same as "Full" but major tick marks are extended across to the opposite axis). The default is "Full".

### Tick Parameters

The Tick Parameters option allows specification of the nature of the numeric tickmark labels to be placed along each axis. This is accomplished with a set of closely inter-related parameters which control the format of the labels. The default values are initially set to "Auto", and provide adequate labels for most data. With the appropriate selection of parameter values, however, many useful labels may be constructed, including fractions and superscripted powers of ten. An excerpt from the NCAR documentation on tick parameters is included in the appendices. Certain incompatible combinations of parameter choices will result in no labels being plotted or error messages generated by the NCAR Autograph utility. These errors will cause the program to terminate. To recover, restart and change the parameters. A menu option is provided to "reset" these parameters to "Auto", so that the default values may be used. Refer to Section 5.9 (Postplot) for several examples of numeric tickmark labels. The Screen fields accessed from this option are:

Base -Two numeric fields for the computation of major tick marks along the X and Y axes. The user may accept the default value of "Auto" which allows the system to select the appropriate value, or enter a value appropriate for the variable selected.

Type - Two toggle fields for selecting a formula for computing (using Base, entered above) the spacing of the tick marks along the X and Y axes. The available choices are:

Auto (System will select appropriate computation)
None (No tick marks on axis)
- Base * k
- Base * 10^k
- Base^k

Note: "k" is an arbitrary integer computed by the program The default value is "Auto" for both axes.

Label - Two toggle fields for selecting the format of numeric label to be used at the major tick marks along the X and Y axes. The available choice are:

| | |
|---|---|
| Auto | - System will select appropriate format |
| None | - No tick marks on axis |
| Scien. | - Scientific notation |
| Expon. | - Exponential notation |
| No-Exp. | - Non-exponential notation |

Fraction -Two numeric fields for entering the number of significant digits to display in the numeric labels along the X and Y axes.

Exponent -Two numeric fields for entering the value of the exponent in the numeric labels along the X and Y axes.

**Graph Limits**

The Graph Limits option allows you to enter values that specify the coordinate limits and the type of scaling for the X and Y axes. Certain combinations of the Tick Parameters will cause these values to be overridden. The screen fields accessed from this option are:

Min - Two numeric fields for entering the minimum coordinate value to be used on the X and Y axes. The default values displayed are determined from the data file for the variable selected as the X and Y variables.

Max - Two numeric fields for entering the maximum coordinate value to be used on the X and Y axes. The default values displayed are determined from the data file for the variable selected as the X and Y variables.

Scale - Two toggle fields for selecting the type of scaling to be used on the X and Y axes. The choices available are "Linear" and "Log" (natural log) scaling. If "Log" scaling is selected and any data values are negative or zero, an error message is displayed and the Scale field is reset to "Linear". The default is "Linear".

### Titles/Labels

The Titles/Labels option allows you to enter the title and labels for the graph. The Hershy character sets of 33 fonts are used for plotting alphanumeric labels. Also, certain "special characters" may be embedded in the title or label which control selection of alternate fonts or other aspects of the plotted text. These special characters are not plotted, but are interpreted as commands by the metacode translator software. The file HERSHY.BAR (included with the software) contains the font information. See the appendices for more information on font selection codes.

The screen fields accessed from this menu option are:

Main title - An alphanumeric field which may contain up to 60 characters for the main title of the graph. The default title contains the variable name selected as the post variable and the name of the data file.

Subtitles - Two alphanumeric fields which may contain up to 60 characters each for the subtitles on the graph. The subtitles appear below the main title.

X Label - An alphanumeric field which may contain up to 60 characters for the X axis label. The default label is composed of the X variable name followed by its units in parentheses.

Y Label - An alphanumeric field which may contain up to 60 characters, for the label on the Y axis. The default label is composed of the Y variable name followed by its units in parentheses.

### Reset

The Reset option allows the user to reset the parameters to their default values.

## SECTION 15

## CONREC

### 15.1 WHAT CONREC DOES

Conrec produces contour maps of variables with gridded coordinates in a Geo-EAS data file. The data must form a complete grid. A grid is a a set of values with equally spaced X and Y coordinates which form a rectangle. Individual grid cells may contain missing values. Default parameter values can be computed for all options, providing instant results. Options allow control of contour levels, labeling, and smoothing. Options to control axes labeling and titles are also available. A file called a "metacode" file is created for redisplay or producing a hardcopy.

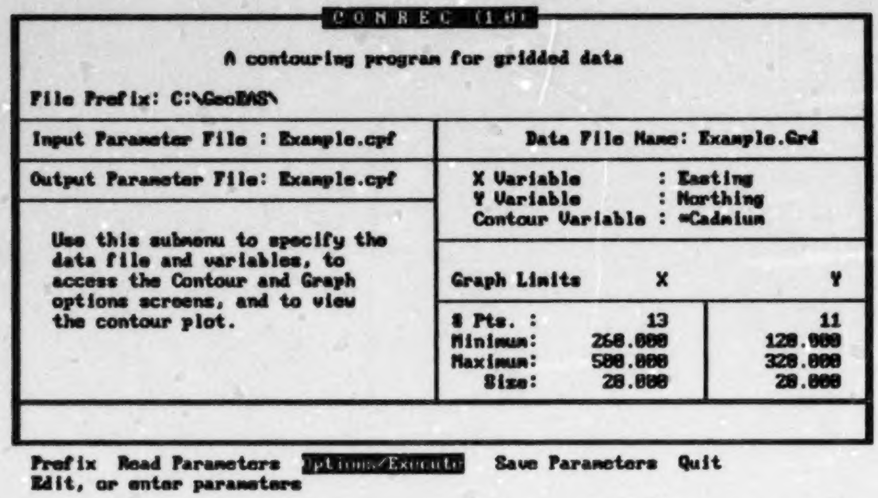
### 15.2 DATA LIMITS

Conrec requires that the input data file contains at least three but not more than 48 variables. These should consist of (at minimum) an X and Y coordinate, and a third variable for which contour lines will be drawn. The data file may contain up to 10000 samples. These must form a grid with no more than 100 elements in each direction. If these limits are exceeded the grid cannot be formed and the data file cannot be used by Conrec.

### 15.3 THE MENU HIERARCHY

```
 Conrec --- Prefix
          | Read Parameters
          | Option/Execute --- Data
          |                  | Variables
          |                  | Graph Options ---- Axes Parameters
          |                  |                  | Tick Parameters
          |                  |                  | Titles/Labels
          |                  |                  | Annotation
          |                  |                  \ Quit
          |                  |
          |                  | Contour Options -- New Levels
          |                  |                  | Edit Levels
          |                  |                  | Labeling
          |                  |                  | Dash Pattern
          |                  |                  | Annotation
          | Save Parameters  | Execute          | Spline
          \ Quit             \ Quit             \ Quit
```

## 15.4 THE MAIN MENU



```
                         CONREC (1.0)
                A contouring program for gridded data

File Prefix: C:\GeoEAS\

Input Parameter File : Example.cpf    Data File Name: Example.Grd

Output Parameter File: Example.cpf     X Variable       : Easting
                                       Y Variable       : Northing
                                       Contour Variable : *Cadmium
  Use this submenu to specify the
  data file and variables, to
  access the Contour and Graph        Graph Limits     X               Y
  options screens, and to view
  the contour plot.                   # Pts. :         13              11
                                      Minimum:    260.000         120.000
                                      Maximum:    500.000         320.000
                                         Size:     20.000          20.000

Prefix  Read Parameters  Options/Execute  Save Parameters  Quit
Edit, or enter parameters
```

Figure 15-1    Conrec Main Screen

The Main screen and menu (Figure 15-1) has the options to allow specification of the input and output parameter file names. The menu line appears as follows:

```
Prefix  Read Parameters  Options/Execute  Save Parameters  Quit
```

**Prefix**

The Prefix option is used to enter the prefix for file names.

**Read Parameters**

The Read Parameters option is used to enter the input parameter file name.

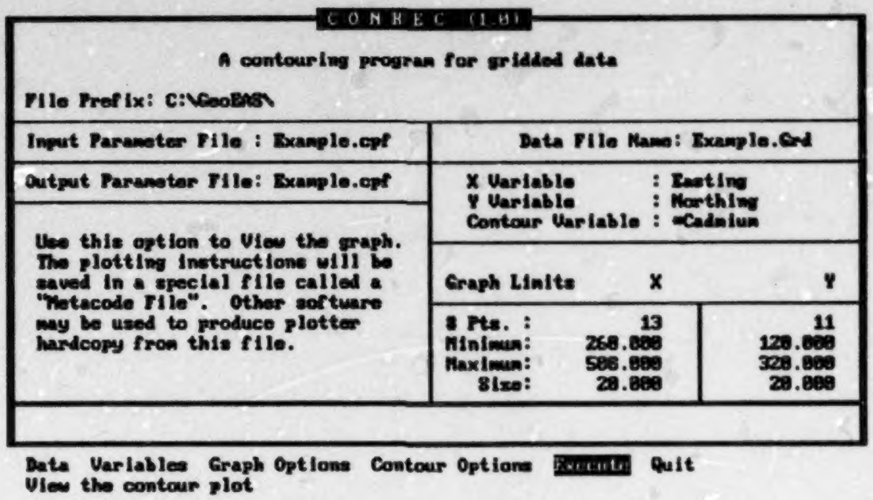
**Options/Execute**

The Options/Execute option provides access to the Options menu. See the section on Options below for more information.

**Save Parameters**

The Save Parameters option is used to enter the name of the output parameter file. The default output parameter file name is the data file name with a ".cpf" extension. If the file specified already exists, a Yes/No prompt for whether or not to overwrite the file is displayed. This file will contain the current parameter values. It will be saved for future use as an input parameter file.

## 15.5 THE OPTIONS MENU



```
                    CONREC (1.0)
          A contouring program for gridded data

File Prefix: C:\GeoEAS\

Input Parameter File : Example.cpf    Data File Name: Example.Grd

Output Parameter File: Example.cpf    X Variable       : Easting
                                      Y Variable       : Northing
                                      Contour Variable : *Cadmium
 Use this option to View the graph.
 The plotting instructions will be
 saved in a special file called a     Graph Limits     X          Y
 "Metacode File".  Other software
 may be used to produce plotter       # Pts. :        13         11
 hardcopy from this file.             Minimum:   260.000    120.000
                                      Maximum:   500.000    320.000
                                         Size:    20.000     20.000

Data  Variables  Graph Options  Contour Options  Execute  Quit
View the contour plot
```

Figure 15-2    Conrec Options Screen

The Options screen and menu, shown in Figure 15-2, has the options to allow specification of the data file name and the selection of variables to be used. The menu line is as follows:

```
Data  Variables  Graph Options  Contour Options  Execute  Quit
```

### Data

The Data option is used to enter the data file name. The file must have coordinate variables with values that form a complete grid. An example of such a file is the file of kriged estimates produced by the program Krige. Krige creates a file with a .grd extension by default. This is a Geo-EAS data file which contains gridded data.

### Variables

The Variables option allows selection of the variables that are to be used as the X and Y coordinate values and the variable to be contoured. The choices available are the variable names as specified in the data file. If a grid could not be formed from the data an error message is displayed. After the grid is formed a Yes/No prompt is displayed which allows computation of defaults for the Graph Options and Contour Options screens. If the response is "Yes" default values for Contour Options and Graph Options options will replace any previous entered values on these screens. If the response is "No" and no contour levels have been set, an error message will occur when the Execute option is selected. The screen fields accessed from this options are:

X Variable - A toggle field for selecting the variable name whose values will be used as the X coordinates. The default X variable is the first variable in the data file.

Y Variable - A toggle field for selecting the variable name whose values will be used as the Y coordinates. The default Y variable is the second variable in the data file.

Contour Variable - A toggle field for selecting the variable name whose values will be used as the contour values. The default Contour Variable is the third variable in the data file.

### Graph Options

The Graph Options option provides access to the Graph Options screen and menu, described below.

### Contour Options

The Contour Options option provides access to the Contour Options screen and menu, described below.

### Execute

When the Execute option is selected, you will be prompted for a metacode file name. The metacode file is then created and the graph is displayed. The metacode file name may be up to 14 characters. The default name is "METACODE.MET". If the default value is not used and the file already exists, a Yes/No prompt provides an option to proceed or quit. The metacode file is stored on disk for later use. A hard copy of the graph can be obtained by using the program Hpplot and an HPGL compatible plotter. If the number of contour levels is set to zero an error message is displayed. The user must set the number of contour levels before the graph can be produced. Contour lines will not be plotted across a grid cell which contains a missing value. After the graph (see Figure 15-3) has been displayed, type <q> to clear the screen and return to the Options menu.

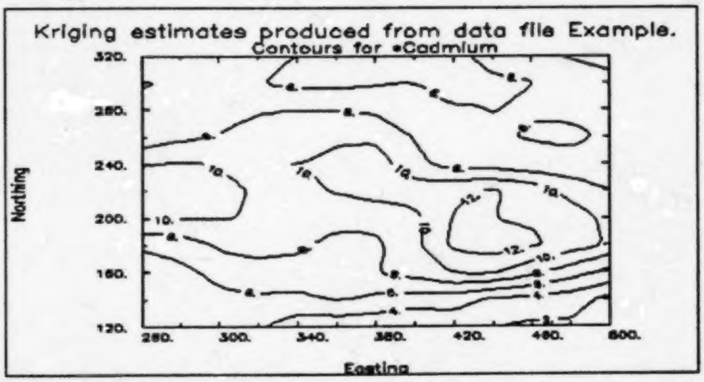
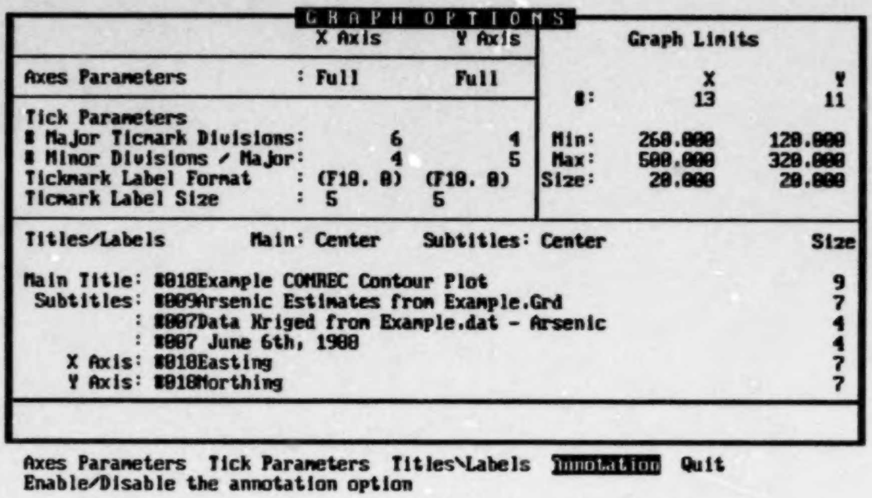


Figure 15-3 Example Contour Plot

## 15.6 THE GRAPH OPTIONS MENU



```
                          GRAPH OPTIONS
                              X Axis      Y Axis   |        Graph Limits
Axes Parameters             : Full        Full     |
                                                   |             X            Y
Tick Parameters                                    |   #:        13           11
# Major Ticmark Divisions:       6           4     |
# Minor Divisions / Major:       4           5     |  Min:    260.000      120.000
Tickmark Label Format       : (F10. 0)  (F10. 0)   |  Max:    500.000      320.000
Ticmark Label Size          :  5         5         | Size:     20.000       20.000

Titles/Labels        Main: Center    Subtitles: Center                      Size

Main Title: #010Example CONREC Contour Plot                                     9
 Subtitles: #009Arsenic Estimates from Example.Grd                              7
          : #007Data Kriged from Example.dat - Arsenic                          4
          : #007 June 6th, 1988                                                 4
    X Axis: #010Easting                                                         7
    Y Axis: #010Northing                                                        7

Axes Parameters  Tick Parameters  Titles\Labels  Annotation  Quit
Enable/Disable the annotation option
```

Figure 15-4 Conrec Graph Options Screen

The Graph Options screen and menu (Figure 15-4) provides control over the "graph background". Options are available to select the axis style, the format for tickmark labeling and spacing, and the character size and orientation of the graph titles and axis labels. The menu line appears as follows:

```
Axis Parameters  Tick Parameters  Titles/Labels  Annotation  Quit
```

### Axis Parameters

The Axis Parameters option allows selection of the type of axis style for the X and Y axes. The screen field accessed from this option is Axis Style which consists of two toggle fields. The choices available are "Half" (left and bottom axes only), "Full" (left, right, top, and bottom axes) and "Grid" (the same as "Full", but the major tickmarks extend across to the opposite axis). The Axis Style for the axes are independent of each other: for example if the Axis Style is "Half" for the X axis and "Full" for the Y axis, the Bottom, Left, and Right axes would be drawn. The default value is "Full" for both the X and Y axes.

### Tick Parameters

The Tick Parameters option allows the specification of the spacing and format of the numeric tickmark labels on the X and Y axes. The screen fields accessed from this option are:

# Major Tickmark Divisions - Two numeric fields for entering the number of major tickmark divisions along the X and Y axes. The default may be calculated by the program when the Variables option is selected.

# Minor Division/Major - Two numeric fields for entering the number of minor tickmark divisions per major division along the X and Y axes. The default may be calculated by the program when the Variables option is selected.

Tickmark Label Format - An alphanumeric field which may contain up to 10 characters for entering a FORTRAN format specifier which describes how the label is to be printed. The format must a valid FORTRAN format for a REAL value with a format width no greater that 10. A default format is constructed from the grid coordinate values. This format should be adequate for most purposes. If an invalid or unsuitable format specifier is entered an error message is displayed. For more information on FORTRAN format specifiers, refer to a FORTRAN reference manual.

Tickmark Label Size - A toggle field used for selecting the character size of the tickmark labels. The choices available are "1" to "10". The default size is "3". This value works well on the screen, however a smaller size might be more suitable for output to a plotter.

### Titles/Labels

The Titles/Labels option allows you to enter the title and labels for the graph. The Hershey character sets of 33 fonts are used for plotting alphanumeric labels. Also, certain "special characters" may be embedded in the title or label which control selection of alternate fonts or other aspects of the plotted text. These special characters are not plotted, but are interpreted as commands by the metacode translator software. The file HERSHY.BAR (included with the software) contains the font information. See the appendices for more information on font selection codes.

The screen fields accessed from this menu option are:

Title Position - Two toggle fields for selecting the position of the main title and the subtitles. The choices available are "Left" (at the left edge), "Center" (centered on the line), or "Right" (at the right edge). The default is "Center".

Main Title - An alphanumeric field which may contain up to 60 characters, for entering the title of the graph. The default title is the title from the data file.

Subtitles - Three alphanumeric fields which may contain up to 60 characters each for entering the graph subtitles. The default for the first subtitle is the name of the contour variable.

X Axis - An alphanumeric field which may contain up to 60 characters for entering the X axis label. The default X axis label is the X coordinate variable name.

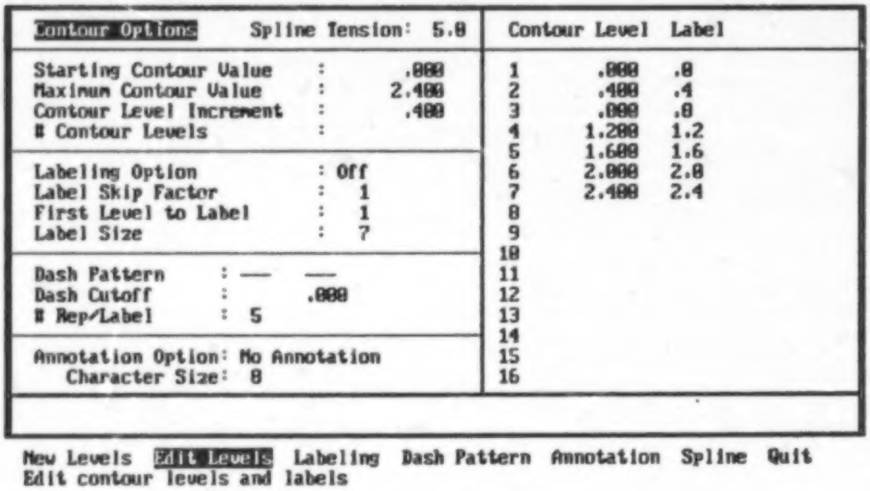
Y Axis - An alphanumeric field which may contain up to 60 characters for entering the Y axis label. The default Y axis label is the Y coordinate variable name.

Size - Six toggle fields for selecting the character size for the labels. The choices available are "0" to "10" where "0" is the smallest and "10" is the largest character size. The default for the Main Title is "6". The default for the first and second subtitles and the X and Y axes is "5". The default for the third subtitle is "4". These choices work well on the screen, however smaller sizes might be more suitable for output to a plotter.

**Annotation**

The Annotation option allows the user to suppress the axes, titles, and labels for the graph. The screen field accessed from this option is a toggle field that is displayed on the message line. The choices available are "Plot axes and titles", or "No annotation" (do not plot axes and titles) . The default is "Plot axes and titles".

## 15.7 THE CONTOUR OPTIONS MENU



```
Contour Options     Spline Tension:  5.0   Contour Level  Label

Starting Contour Value    :      .000      1      .000    .0
Maximum Contour Value     :     2.400      2      .400    .4
Contour Level Increment   :      .400      3      .000    .0
# Contour Levels          :                4     1.200    1.2
                                           5     1.600    1.6
Labeling Option           : Off            6     2.000    2.0
Label Skip Factor         :   1            7     2.400    2.4
First Level to Label      :   1            8
Label Size                :   7            9
                                           10
Dash Pattern      : ——    ——               11
Dash Cutoff       :         .000           12
# Rep/Label       :  5                     13
                                           14
Annotation Option: No Annotation           15
   Character Size:  8                      16

New Levels  Edit Levels  Labeling  Dash Pattern  Annotation  Spline  Quit
Edit contour levels and labels
```

Figure 15-5 Conrec Contour Options Screen

The Contour Options screen and menu (Figure 15-5) has options to allow specification of the contour levels, labels, the skip factor , label size and the selection of a dashed line pattern. The menu line appears as follows:

```
New Levels  Edit Levels  Labeling  Dash Pattern  Annotation  Spline  Quit
```

**New Levels**

The New Levels options allow you create a list of equally spaced contour values and labels. The defaults for these screen fields may be calculated by the program when the Variables option is selected. The program calculates the contour levels and the corresponding labels based on the values from these fields. The screen fields accessed from this option are:

Starting Contour Value - A numeric field for entering the lowest contour level.

Maximum Contour Value - A numeric field for entering the highest contour level.

Contour Level Increment - A numeric field for entering the increment value between the contour levels.

**Edit Levels**

The Edit Levels option allow you to change the contour labels or specify unequal contour level spacing. The screen fields accessed from this option are:

Contour Level - A column of numeric fields for entering the contour levels.

Contour Label - An column of 16 character alphanumeric fields for entering the contour labels.

**Labeling**

The Labeling option allow you to select the contour labeling options. The screen fields accessed from this option are:

Labeling Option - A two valued toggle field to enable or disable the labeling of contour lines. The choices available are "On" (label contours) or "Off" (do not label contours). If the Labeling Option is "Off" the other screen fields in this group are ignored. The default is "On".

Label Skip Factor - A toggle field for selecting the skip factor for the contour labels. The Label Skip Factor is the frequency at which to label the contour lines. For example if the Label Skip Factor is two and the First Level to Label is 1 then contour levels 1, 3, 5 ... would be labeled. The choices available are "1" to "5". The default is "2".

First Level to Label - A ten-valued ("1" .. "10") toggle field for selecting the first contour level to label. The default is "1".

Label Size - A ten-valued toggle field ("1".."10") for selecting the contour label character size. The default is "6".

### Dash Pattern

The Dash Pattern option allows specification of the Dash Pattern and the Dash Cutoff level. The screen fields accessed from this option are:

Dash Pattern - An alphanumeric field which may contain up to 12 characters, for entering the line pattern to use for the contour line below the Dash Cutoff. The Dash Pattern is a combination of characters and spaces with each non-blank character representing a solid line segment in the Dash Pattern. The default is "---   ---   ". The pattern "------------" would cause a solid line to be plotted.

Dash Cutoff - A numeric field for entering the Dash Cutoff value. If a contour level is below this value then the line is plotted using the specified Dash Pattern.

# Rep/Label - A toggle field for selecting the number of repetitions of the dash pattern between contour labels to plot. Choices available are "2" to "10". The default is "5".

### Annotation

The Annotation option allows the specification of the graph annotation. The screen fields accessed from this option are:

Annotation Option - A toggle field for selecting the type of graph annotation for the graph. The available choices are "Plot Min/Max" and "No Annotation" ( do not plot the minimum and maximums. The default is "Plot Min/Max". If "Plot Min/Max" is chosen the minima and maxima of the surface represented by the contour map will be plotted. An "H" denotes a local maximum and an "L" denotes a local minimum.

Character Size - A toggle field for selecting the character size to plot the graph annotation. Choices available are "1" to "10". The default is "8". This value works well on the screen, however a smaller size may be better suitable for output to a plotter. This field is ignored if the Annotation

### Spline

The Spline option allows the specification of the amount of smoothing of the line segments. The screen field accessed from this option is a numeric field. Acceptable values range from 2.5 to 30. The larger the Spline Tension value the less smoothing of the line. A value of 30 disables smoothing. Smooth contours generally look better; but because the contour lines are smoothed independently, smoothing results in contour lines which may intersect. The default value is 15.0.

# SECTION 16

# VIEW

## 16.1 WHAT VIEW DOES

View displays on the screen the graphs contained in metacode files. The graphs can be displayed on a EGA, CGA, or Hercules graphics system. Color graphs are viewed on EGA systems. On CGA and Hercules systems monochrome graphs are displayed.

## 16.2 THE MENU HIERARCHY

```
     View --- Prefix
            | File
            | Scale
            | Execute
            \ Quit
```

## 16.3 THE MAIN MENU

The Main screen and menu, shown in Figure 16-1, has the options to allow specification of the metacode file name and the plotting area. The menu line appears as follows:

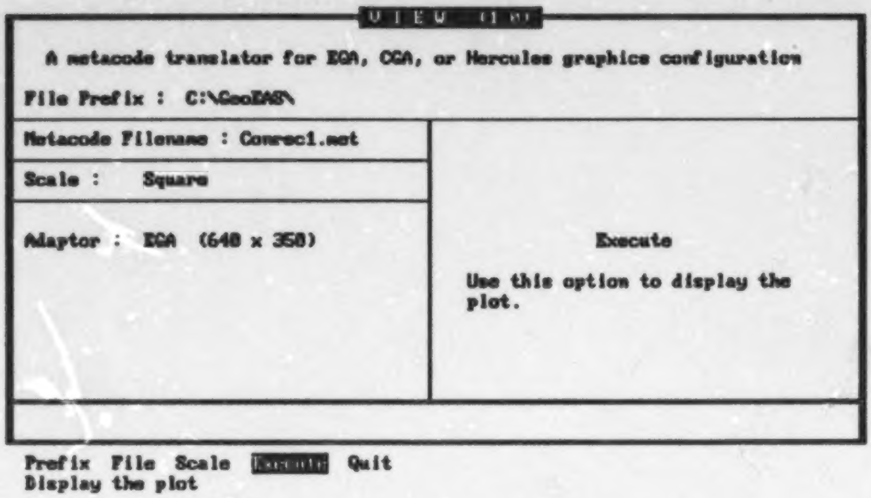
```
Prefix  File  Scale  Execute  Quit
```

**Prefix**

The Prefix option is used to enter the prefix for file names.

**File**

The File option is used to enter the metacode file name. The screen field accessed from this option is an alphanumeric field and may contain up to 14 characters. This character string combined with the file prefix should form the name of a valid metacode file, or an error is displayed. This file contains the metacode instructions produced by the programs, Conrec, Xygraph, and Postplot.



A metacode translator for EGA, CGA, or Hercules graphics configuration

File Prefix : C:\GeoEAS\

Metacode Filename : Conrec1.met

Scale : Square

Adaptor : EGA (640 x 350)

Execute

Use this option to display the plot.

Display the plot

Figure 16-1 View Main Screen

**Scale**

The Scale option is used to select the type of plotting area to use when displaying the graph. The screen field accessed from this option is a toggle field. The choices available are "Square" (the original scaling of the graph), and "Rectangle" (the graph will be stretched to fit the entire screen). The default is "Rectangle".

**Execute**

The Execute option is used to display the graph on the screen. When this option is selected the metacode file is read and translated into graphic output for the type of graphic system in use. If a problem is encountered while trying to read the metacode file an error message will be displayed. This can occur if the specified file is not in the correct format. The metacode file can contain more than one graph (frame). To View subsequent frames press <enter>. After the graph has been displayed, type <q> to clear the screen to return to the Main menu.

## SECTION 17

## HPPLOT

### 17.1 WHAT HPPLOT DOES

Hpplot translates the device independent plotting instructions in metacode files into a file of HPGL plotting commands. The output file can be routed to a HP plotter by setting up the serial port (COM1) by running the batch file HPSETUP.BAT and then using the DOS PRINT command to send the file to the plotter. The HP plotters supported are:

HP 7470 - 2 pen plotter

HP 7475 - 6 pen plotter

HP 7450 - 8 pen plotter

If the HP 7470 is used for plotting the graph will be plotted in two pen colors, the program does not prompt for pen changes.

### 17.2 THE MENU HIERARCHY

```
Hpplot --- Prefix
          | File
          | Scale
          | Execute
          \ Quit
```

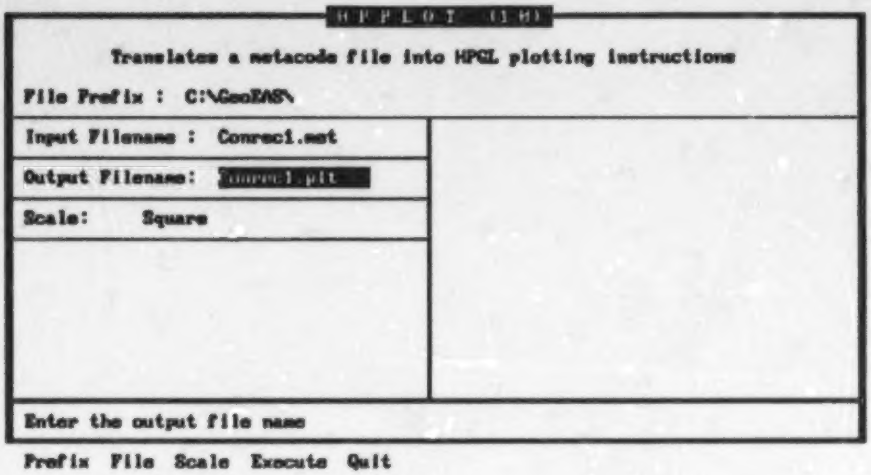
### 17.3 THE MAIN MENU

The Main screen and menu (Figure 17-1) has the options to allow specification of the metacode and output file names, and the plotting area. The menu line appears as follows:

```
Prefix  File  Scale  Execute  Quit
```

**Prefix**

The Prefix option is used to enter the prefix for file names.



Translates a metacode file into HPGL plotting instructions

File Prefix : C:\GeoEAS\

Input Filename : Conrec1.met

Output Filename: Conrec1.plt

Scale: Square

Enter the output file name

Figure 17-1 Hpplot Main Screen

**File**

The File option is used to enter the metacode file name. The screen field accessed from this option is an alphanumeric field and may contain up to 14 characters. This character string combined with the file prefix should form the name of a valid metacode file, or an error is displayed. This file contains the metacode instructions produced by the programs Conrec, Xygraph, or Postplot.

**Scale**

The Scale option is used to select the type of plotting area to use when displaying the graph. The screen field accessed from this option is a toggle field. The choices available are "Square" (the true scale of the graph), and "Rectangle" (the entire screen). The default is "Rectangle".

**Execute**

When the Execute option is selected, you will be prompted for a output file name before the output file is created. The output file name entered must be up to 14 characters. This file contains the instruction generated by translating the metacode file into HPGL plotting instructions. If a problem occurs while accessing the metacode file an error message is displayed. When execution is complete, the plot instruction file produced by Hpplot may be sent to an HP plotter or compatible. This is accomplished by first running the DOS command file HPSETUP.BAT (provided with the software distribution) to configure the COM1: serial port, and redirect printer output to COM1:. **Type: HPSETUP <enter>**. The file may then be sent to the plotter by using the DOS command: **PRINT (Filename) <enter>**.

## APPENDIX A

## REFERENCES

Journel, A.G. and C.H. Huijbregts, 1978, Mining Geostatistics, Academic Press, London.

David, M., 1984, Geostatistical Ore Reserve Estimation, Elsevier, Amsterdam.

Clark, I., 1979, Practical Geostatistics, Applied Science Publishers, London.

Rendu, J.M., 1981, An Introduction to Geostatistical Methods of Mineral Evaluation, South African Institute of Mining and Metalurgy, Johannesburg.

Srivastava, R.M., 1988, "A Non-ergodic Framework for Variograms and Covariance Functions", SIMS Technical Report No. 114, Dept. of Applied Earth Sciences, Stanford University.

# APPENDIX B

## NCAR Graph Options

The following is an excerpt from the NCAR Autograph Manual. It has been slightly modified to include the Tickmark parameter names used in programs Xygraph and Postplot. This explanation may help to explain how these parameters work together to produce numeric tickmark labels. Acceptable actual values for the screen fields are as follows:

**No Labeling**

- Setting Label to 'None' turns off the numeric labels on the axis specified. The other parameters, are then ignored.

**Scientific Labeling**

- Setting Label to 'Scien.' selects scientific notation. Each numeric label is written in the form:

[-] [i] [.] [f] * 10 e

Where brackets enclose portions which may be independently present or absent and 'e' is a superscript exponent.

The value of the parameter Type is immaterial when scientific notation is selected.

The parameter Exponent specifies the number of character of 'i', thus also specifying the value of the exponent 'e'. IF Exponent has a value less than or equal to zero, 'i' is omitted. If Exponent is less than zero and has the integral absolute value 'n', the fraction 'f' is forced to have 'n' leading zeroes.

The parameter Fraction specifies the number of characters in 'f'. If Fraction is less than or equal to zero, 'f' is omitted. If Fraction is less than zero, the decimal point is omitted.

If "[i] [.] [f]" has the value '1.', the first part of the label is omitted, leaving only '10 e'.

If the entire label has the value '0.', the single character '0.' is used.

**Exponent Labeling**

- Setting Label to 'Expon.' selects exponential notation.

  - If the parameter Type has the value • Base*k. Each numeric label is written in the form:

    [-] [i] [.] [f] * 10 e

    Where brackets enclose portions which may be independently present or absent and 'e' is a superscript exponent.

    The parameter Exponent specifies the integral value of the exponent 'e'.

    The parameter Fraction specifies the number of characters in 'f'. If Fraction is less than or equal to zero, 'f' is omitted. If Fraction is less than zero, the decimal point is omitted.

    If the label is exactly zero, the single character '0' is used.

  - If the parameter Type has the value • Base*10^k. Each numeric label is written in the form:

    [-] [i] [.] [f] * 10 e

    The parameter Exponent specifies the integral value of the exponent 'e' when 'k' equals '0.'. The value of 'e' is Exponent plus 'k'.

    The parameter Fraction specifies the number of characters in 'f'. If Fraction is less than or equal to zero, 'f' is omitted. If Fraction is less than zero, the decimal point is omitted.

    If the label is exactly zero, the single character '0' is used.

  - If the parameter Type has the value • Base^k. Each numeric label is written in the form:

    [-] [i] [.] [f] e

    The parameter Exponent is ignored. The value of 'e' is 'k'.

    The parameter Fraction specifies the number of characters in 'f'. If Fraction is less than or equal to zero, 'f' is omitted. If Fraction is negative, the decimal is omitted.

(Note that '[i] [.] [f]' expresses the value of Base.)

**Non-exponent Labeling**

- Setting Label to 'No-Exp.' selects non-exponent notation. The parameter Exponent is ignored.

  - If the parameter Type has the value • Base*k. Each numeric label is written in the form:

    [-] [i] [.] [f]

    The parameter Fraction specifies the number of characters in 'f'. If Fraction is less than or equal to zero, 'f' is omitted. If Fraction is less than zero, the decimal point is omitted. If the label is exactly zero, the single character '0' is used.

  - If the parameter Type has the value • Base*10^k. Each numeric label is written in the form:

    [-] [i] [.] [f]

    The parameter Fraction specifies the number of characters in 'f' when 'k' is zero .If Fraction is less than or equal to zero, 'f' is omitted. If Fraction is less than zero, the decimal point is omitted.

    For example, if Fraction = 1., Base = 3.6, and k ranges from -3 to +3; the labels produces are

    .0036, .036, .36, 3.6, 36. 360., and 3600.

  - If the parameter Type has the value • Base^k. Each numeric label is written in the form:

    [-] [i] [.] [f]

    if 'k' is greater than or equal to zero, and in the form

    [-] 1/ [i] [.] [f]

    if 'k' is less than zero.

    The parameter Fraction specifies the number of characters in 'f' when 'k' is equal to 1.. If Fraction is less than or equal to zero, 'f' is omitted. If Fraction is less than zero, the decimal point is omitted. For example, if Fraction = -1., Base = 2., and k ranges from -4 to +4; the labels produced are:

    1/16, 1/8, 1/4, 1/2, 1, 2, 4, 8, 16

# APPENDIX C

## Hershy Character Font Tables

The Hershy character set consists of 33 different character fonts, numbered 0 through 32. This information is stored in a machine-readable file called 'HERSHY.BAR', which is included with the software distribution. The font descriptions indicate the extent to which the characters contain tapered segments (simplex, duplex, complex, triplex, or gothic), and the size of the characters ( cartographic, indexical, principal, or centered symbol). The following table lists available fonts and font codes.

| FONT | DESCRIPTION |
|---|---|
| 0 | Cartographic Roman |
| 1 | Cartographic Greek |
| 2 | Simplex Roman |
| 3 | Simplex Greek |
| 4 | Simplex Script |
| 5-6 | Simplex Special Characters |
| 7 | Complex Roman |
| 8 | Complex Greek |
| 9 | Complex Italic |
| 10-11 | Complex Special Characters |
| 12 | Complex Roman |
| 13 | Complex Greek |
| 14 | Complex Italic |
| 15-17 | Complex Special Characters |
| 18-19 | Duplex Roman |
| 20-21 | Complex Script |
| 22-23 | Complex Cyrillic |
| 24-25 | Triplex Roman |
| 26-27 | Triplex Italic |
| 28 | Gothic German |
| 29 | Gothic English |
| 30 | Gothic Italian |
| 31 | Gothic Special Characters |
| 32 | Centered Symbols |

Certain 'special characters' are used to inform the graphics software that this font information is to be used for plotting. These characters may be embedded in graph titles or labels, and will allow selection of alternate font types, and other special features. These special characters are not plotted, but are instead interpreted as commands by the metacode translator software. The special characters and their meanings are:

" - backspace one character position
# - indicates a three-digit font selection code follows
% - selects the default font
< - subscript the next character
> - superscript the next character

The figure below illustrates the results of using the following five characters strings:

#004Geostatistical Environmental Assessment Software%

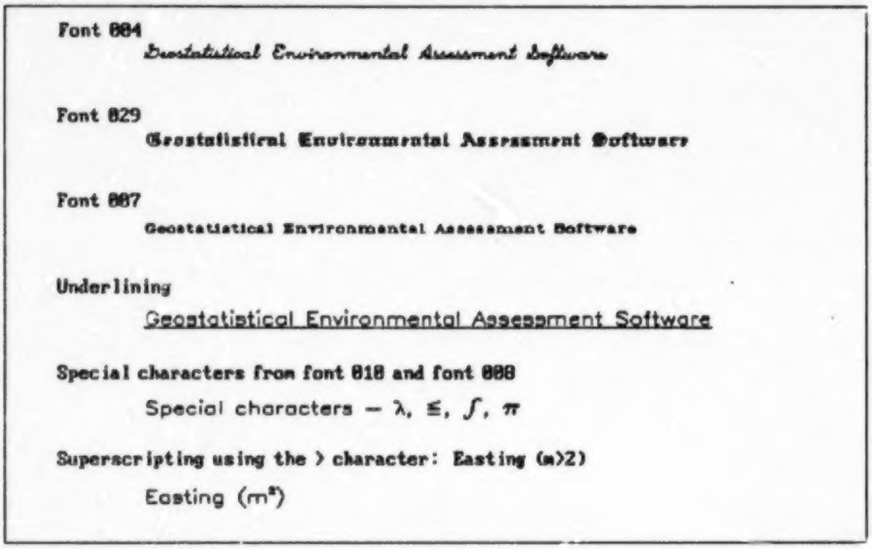
#027Geostatistical Environmental Assessment Software%

#007Geostatistical Environmental Assessment Software%

_Geostatistical Environmental Assessment Software_

Special characters - #003k%, #010Q%, #010t%, #008p%

Easting (M>2)



Font 004
Geostatistical Environmental Assessment Software

Font 029
Geostatistical Environmental Assessment Software

Font 007
Geostatistical Environmental Assessment Software

Underlining
Geostatistical Environmental Assessment Software

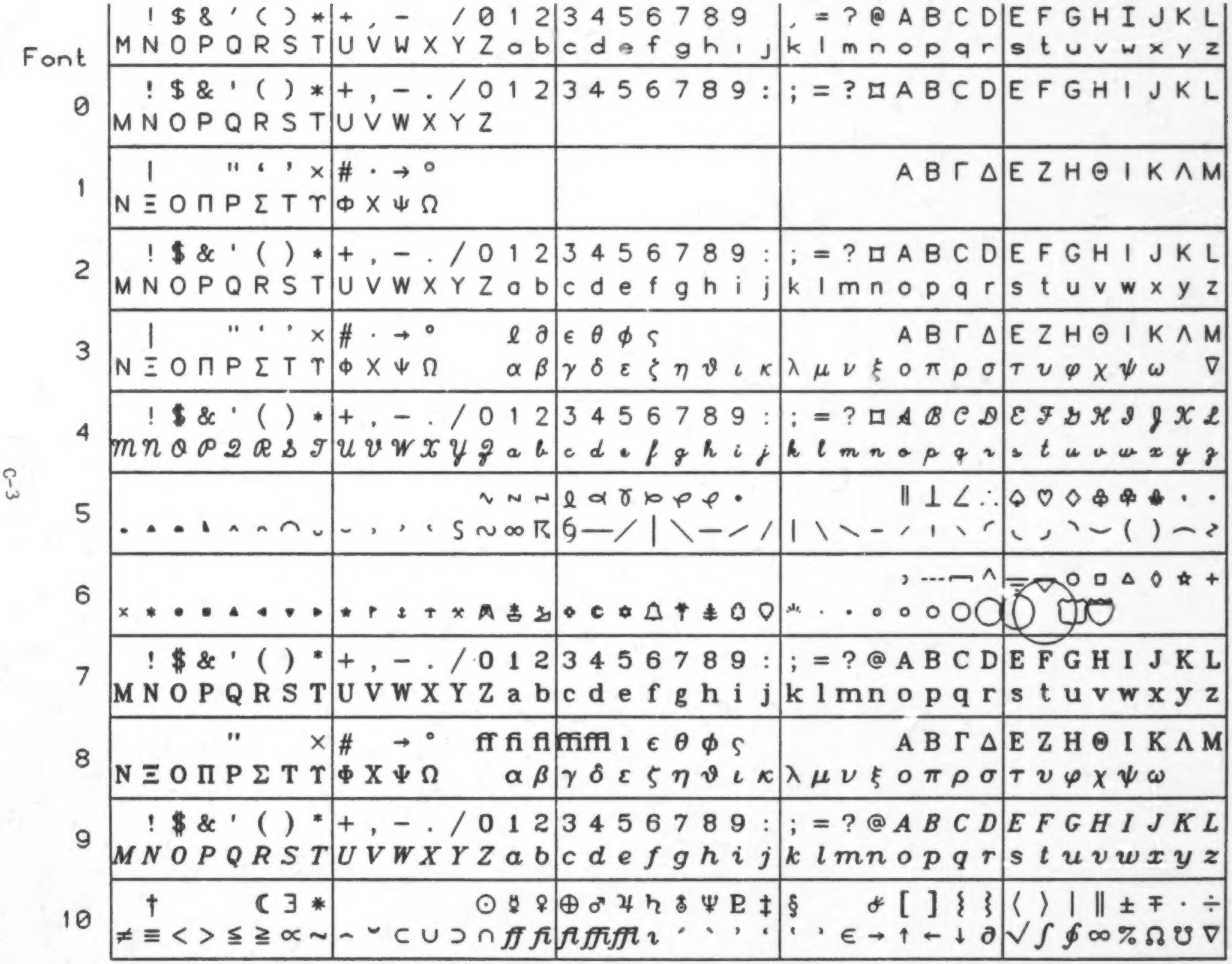
Special characters from font 010 and font 008
Special characters — λ, ≤, ∫, π

Superscripting using the > character: Easting (m>2)
Easting (m$^2$)

Figure C-1     Example font selection codes

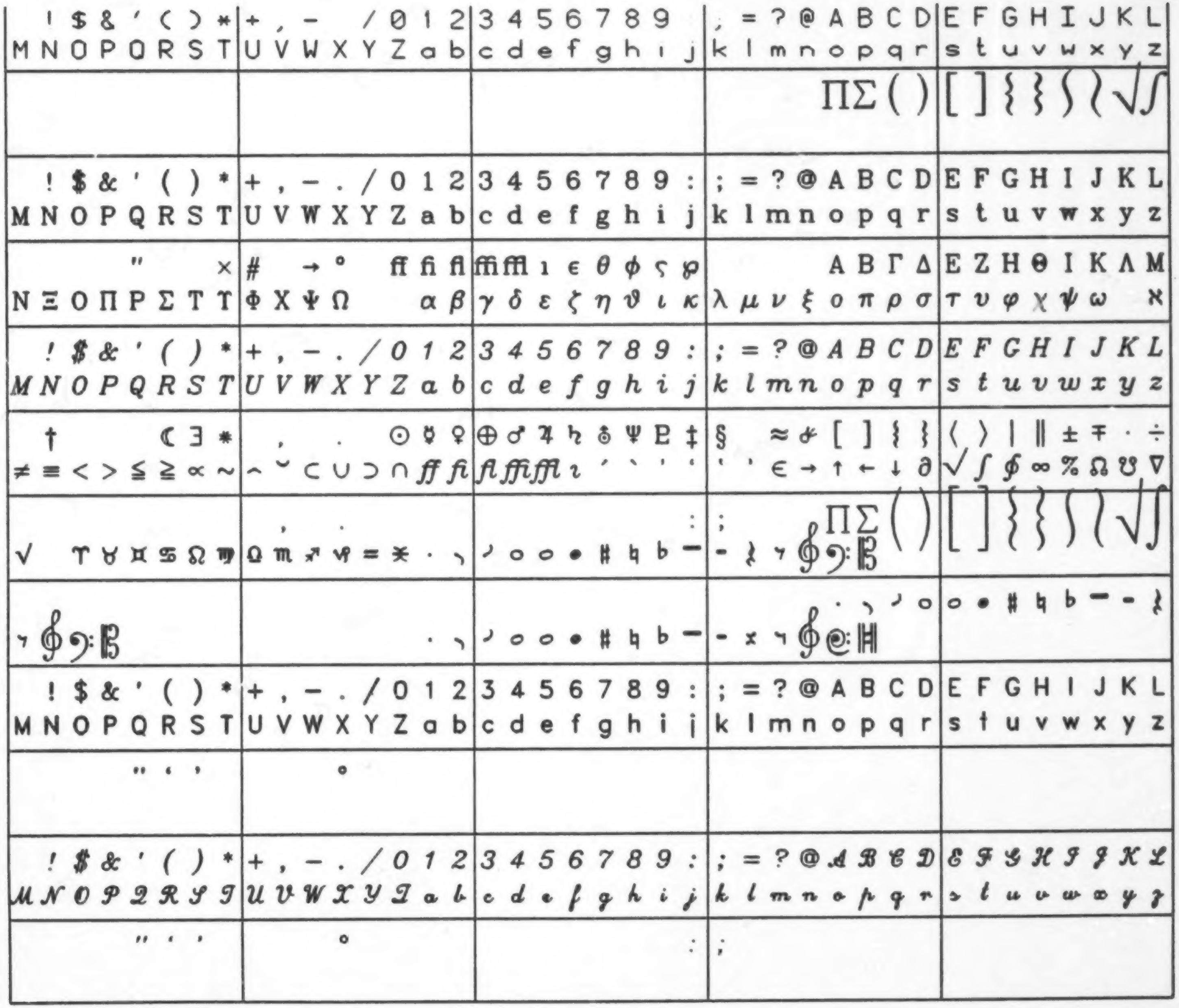
The following table illustrates all font groups, and symbols within each group:

## ASCII Character



| Font | | | | | |
|---|---|---|---|---|---|
| | ! $ & ' ( ) *<br>M N O P Q R S T | + , - / 0 1 2<br>U V W X Y Z a b | 3 4 5 6 7 8 9<br>c d e f g h i j | , = ? @ A B C D<br>k l m n o p q r | E F G H I J K L<br>s t u v w x y z |
| 0 | ! $ & ' ( ) *<br>M N O P Q R S T | + , - . / 0 1 2<br>U V W X Y Z | 3 4 5 6 7 8 9 : | ; = ? ⌑ A B C D | E F G H I J K L |
| 1 | \| " ' ' ×<br>N Ξ O Π P Σ T ϒ | # · → °<br>Φ X Ψ Ω | | A B Γ Δ | E Z H Θ I K Λ M |
| 2 | ! $ & ' ( ) *<br>M N O P Q R S T | + , - . / 0 1 2<br>U V W X Y Z a b | 3 4 5 6 7 8 9 :<br>c d e f g h i j | ; = ? ⌑ A B C D<br>k l m n o p q r | E F G H I J K L<br>s t u v w x y z |
| 3 | \| " ' ' ×<br>N Ξ O Π P Σ T ϒ | # · → ° ℓ ∂<br>Φ X Ψ Ω α β | ϵ θ ϕ ς<br>γ δ ε ζ η ϑ ι κ | A B Γ Δ<br>λ μ ν ξ ο π ρ σ | E Z H Θ I K Λ M<br>τ υ φ χ ψ ω ∇ |
| 4 | ! $ & ' ( ) *<br>M N O P Q R S T | + , - . / 0 1 2<br>U V W X Y Z a b | 3 4 5 6 7 8 9 :<br>c d e f g h i j | ; = ? ⌑ A B C D<br>k l m n o p q r | E F G H I J K L<br>s t u v w x y z |
| 5 | • ▴ • ▴ ^ ⌢ ∩ ⌣ | ∿ ≂ ⌐<br>⌣ , ' ‘ S ∿ ∞ ℞ | ♌ ♉ ♈ ♓ ℘ ℘ •<br>♋ — / \| \ — / / | ‖ ⊥ ∠ ∴<br>\| \ \ - / ı \ ⌜ | ♠ ♡ ◇ ♣ ♣ ♣ • •<br>◟ ◞ ◝ ‿ ( ) ⌢ ≀ |
| 6 | × ✱ ● ■ ▲ ◀ ▼ ▶ | ★ ⚑ ⚓ ⊤ ✕ ⩚ ♗ ♘ | ✧ ☾ ✡ △ † ⸸ ♘ ♡ | › ‐‐‐ ⌐ ^<br>⁂ · • ∘ ○ ○ ○ ◯ | ≡ ▽ ○ □ △ ◇ ☆ +<br>◯ ◯ ⛉ ⛉ |
| 7 | ! $ & ' ( ) *<br>M N O P Q R S T | + , - . / 0 1 2<br>U V W X Y Z a b | 3 4 5 6 7 8 9 :<br>c d e f g h i j | ; = ? @ A B C D<br>k l m n o p q r | E F G H I J K L<br>s t u v w x y z |
| 8 | " ×<br>N Ξ O Π P Σ T ϒ | # → ° ﬀ ﬁ ﬂ<br>Φ X Ψ Ω α β | ﬃ ﬄ ı ϵ θ ϕ ς<br>γ δ ε ζ η ϑ ι κ | A B Γ Δ<br>λ μ ν ξ ο π ρ σ | E Z H Θ I K Λ M<br>τ υ φ χ ψ ω |
| 9 | ! $ & ' ( ) *<br>*M N O P Q R S T* | + , - . / 0 1 2<br>*U V W X Y Z a b* | 3 4 5 6 7 8 9 :<br>*c d e f g h i j* | ; = ? @ *A B C D*<br>*k l m n o p q r* | *E F G H I J K L*<br>*s t u v w x y z* |
| 10 | † ☾ ∃ *<br>≠ ≡ < > ≦ ≧ ∝ ~ | ⊙ ☿ ♀<br>⌢ ˘ ⊂ ∪ ⊃ ∩ ﬀ ﬁ | ⊕ ♂ ♃ ♄ ♅ ♆ ♇ ‡<br>ﬂ ﬃ ﬄ ı ´ ` ' ‘ | § ♭ [ ] { }<br>‘ ’ ∈ → ↑ ← ↓ ∂ | ⟨ ⟩ \| ‖ ± ∓ · ÷<br>√ ∫ ∮ ∞ % Ω ℧ ∇ |

## ASCII Character



| Font | ! $ & ' ( ) *<br>M N O P Q R S T | + , - / 0 1 2<br>U V W X Y Z a b | 3 4 5 6 7 8 9<br>c d e f g h i j | ; = ? @ A B C D<br>k l m n o p q r | E F G H I J K L<br>s t u v w x y z |
|---|---|---|---|---|---|
| 11 | | | | Π Σ ( ) | [ ] { } ∫ ≀ √ ∫ |
| 12 | ! $ & ' ( ) *<br>M N O P Q R S T | + , - . / 0 1 2<br>U V W X Y Z a b | 3 4 5 6 7 8 9 :<br>c d e f g h i j | ; = ? @ A B C D<br>k l m n o p q r | E F G H I J K L<br>s t u v w x y z |
| 13 | " ×<br>N Ξ Ο Π Ρ Σ Τ Τ | # → ° ﬀ ﬁ ﬂ<br>Φ Χ Ψ Ω α β | ﬃ ﬄ ı ϵ θ ϕ ς ℘<br>γ δ ε ζ η ϑ ι κ | Α Β Γ Δ<br>λ μ ν ξ ο π ρ σ | Ε Ζ Η Θ Ι Κ Λ Μ<br>τ υ φ χ ψ ω ℵ |
| 14 | *! $ & ' ( ) **<br>*M N O P Q R S T* | *+ , - . / 0 1 2*<br>*U V W X Y Z a b* | *3 4 5 6 7 8 9 :*<br>*c d e f g h i j* | *; = ? @ A B C D*<br>*k l m n o p q r* | *E F G H I J K L*<br>*s t u v w x y z* |
| 15 | † ☾ ∃ *<br>≠ ≡ < > ≦ ≧ ∝ ~ | , . ⊙ ☿ ♀<br>^ ˘ ⊂ ∪ ⊃ ∩ ﬀ ﬁ | ⊕ ♂ ♃ ♄ ♅ ♆ ♇ ‡<br>ﬂ ﬃ ﬄ ı ´ ` ' ' | § ≈ ∉ [ ] { }<br>' ' ∈ → ↑ ← ↓ ∂ | ⟨ ⟩ \| ‖ ± ∓ · ÷<br>√ ∫ ∮ ∞ % Ω ℧ ∇ |
| 16 | √ ♈ ♉ ♊ ♋ ♌ ♍ | , .<br>♎ ♏ ♐ ♑ = ⁎ · ⌐ | :<br>♪ o o ● ♯ ♮ ♭ — | ;<br>- 𝄽 ⌐ 𝄞 𝄢 𝄡 Π Σ ( ) | [ ] { } ∫ ≀ √ ∫ |
| 17 | ⌐ 𝄞 𝄢 𝄡 | . ⌐ | ♪ o o ● ♯ ♮ ♭ — | . ⌐ ♪ o<br>- × ⌐ 𝄞 𝄴 𝄃 | o ● ♯ ♮ ♭ — - 𝄽 |
| 18 | ! $ & ' ( ) *<br>M N O P Q R S T | + , - . / 0 1 2<br>U V W X Y Z a b | 3 4 5 6 7 8 9 :<br>c d e f g h i j | ; = ? @ A B C D<br>k l m n o p q r | E F G H I J K L<br>s t u v w x y z |
| 19 | " ' ' | ° | | | |
| 20 | *! $ & ' ( ) **<br>*𝓜 𝓝 𝓞 𝓟 𝓠 𝓡 𝓢 𝓣* | *+ , - . / 0 1 2*<br>*𝓤 𝓥 𝓦 𝓧 𝓨 𝓩 a b* | *3 4 5 6 7 8 9 :*<br>*c d e f g h i j* | *; = ? @ 𝓐 𝓑 𝓒 𝓓*<br>*k l m n o p q r* | *𝓔 𝓕 𝓖 𝓗 𝓘 𝓙 𝓚 𝓛*<br>*s t u v w x y z* |
| 21 | " ' ' | ° | : | ; | |

| Font | ASCII Character | | | | |
|---|---|---|---|---|---|
| | ! $ & ' ( ) *<br>M N O P Q R S T | + , - / 0 1 2<br>U V W X Y Z a b | 3 4 5 6 7 8 9<br>c d e f g h i j | , = ? @ A B C D<br>k l m n o p q r | E F G H I J K L<br>s t u v w x y z |
| 22 | ! $ & ' ( ) *<br>М Н О П Р С Т У | + , - . / 0 1 2<br>Ф Х Ц Ч Ш Щ а б | 3 4 5 6 7 8 9 :<br>в г д е ж з и й | ; = ? @ А Б В Г<br>к л м н о п р с | Д Е Ж З И Й К Л<br>т у ф х ц ч ш щ |
| 23 | | ъ ы | ь э ю я | Ъ Ы Ь Э | Ю Я |
| 24 | ! $ & ' ( ) *<br>M N O P Q R S T | + , - . / 0 1 2<br>U V W X Y Z a b | 3 4 5 6 7 8 9 :<br>c d e f g h i j | ; = ? @ A B C D<br>k l m n o p q r | E F G H I J K L<br>s t u v w x y z |
| 25 | " ‘ ’ | ° | | | |
| 26 | *! $ & ' ( ) *<br>M N O P Q R S T* | *+ , - . / 0 1 2<br>U V W X Y Z a b* | *3 4 5 6 7 8 9 :<br>c d e f g h i j* | *; = ? @ A B C D<br>k l m n o p q r* | *E F G H I J K L<br>s t u v w x y z* |
| 27 | " ‘ ’ | ° | | | |
| 28 | ! $ & ' ( ) *<br>M N O P Q R S T | + , - ' = 0 1 2<br>U V W X Y Z a b | 3 4 5 6 7 8 9 :<br>c d e f g h i j | ; = ? A B C D<br>k l m n o p q r | E F G H I J K L<br>s t u v w x y z |
| 29 | ! $ & ' ( ) *<br>M N O P Q R S T | + , - . / 0 1 2<br>U V W X Y Z a b | 3 4 5 6 7 8 9 :<br>c d e f g h i j | ; = ? A B C D<br>k l m n o p q r | E F G H I J K L<br>s t u v w x y z |
| 30 | ! $ & ' ( ) *<br>M N O P Q R S T | + , - . / 0 1 2<br>U V W X Y Z a b | 3 4 5 6 7 8 9 :<br>c d e f g h i j | ; = ? A B C D<br>k l m n o p q r | E F G H I J K L<br>s t u v w x y z |
| 31 | " ‘ ’<br>§ | ° | | | ß ſ |
| 32 | □ ○ △ + × ◇ ↟ ⊼ | Ƶ Y ¤ ✳ ⧗ I ⊗ ✡ | A ● ✥ 卍 ⌘ ■ ▲ ○ | ◆ ¤ ✳ ● ✱ □ × □ | ■ ● ◘ ⧗ ✤ |

## APPENDIX D

## POLYGON FILE FORMAT

This section describes the format of a polygon file. They are used by program KRIGE to include or exclude computation of estimates within specified polygonal areas. Polygon files are text files comprised of lists of X,Y coordinate pairs (vertices) which form closed polygonal boundaries. These boundaries may be defined as inclusive or exclusive, meaning that estimates should be excluded outside of inclusive boundaries, and included when outside of exclusive boundaries.

The Polygon File is processed in the following manner: Krige reads the specified polygon file before kriging and builds a matrix of flags to indicate if point or block estimates are to be included or excluded. This matrix corresponds to the grid defined by the user in the Krige Options Screen. Polygon files must be contructed with these grid boundaries in mind, because the grid and polygon boundaries are related. As krige reads each polygon from the polygon file, each grid cell center is tested. If the cell center (point or block center) is inside an inclusive polygon, (or outside an exclusive one) the corresponding flag is set to include the estimate. Conversely, if a cell center is outside and inclusive (or inside an exclusive) polygon, the flag is set to exclude computation of an estimate at that location. The rule which governs processing of multiple polygons is this: No flag may be changed to Include an estimate which has been Excluded by a previous polygon.

Polygon files may contain an unlimited number of polygons. The first record (line) in the file should contain the number of polygons contained in the file. Each polygon may be specified as an inclusive (Code 0), or exclusive (Code 1) polygon. A polygon is specified by placing a polygon header record in the file, followed by no more than 100 polygon vertex records. A polygon header record consists of two integers: The Include/ Exclude Code (0, or 1), followed by a comma, and the number of vertices <Nv> in the polygon. Exactly <Nv> vertex records must follow. Each vertex record consists of two floating point (REAL) numbers separated by a comma. These should be listed in an order such that straight lines connecting successive vertices would form a closed polygonal boundary (if a final line were drawn from the last vertex to the first).

Polygon files may be created by any simple text editor such as the DOS editor EDLIN, or any word processor using non-document mode. All lines in the file must be terminated with a CRLF (carriage-return line-feed). Below is an example of a polygon file containing an inclusive square polygon, with an exclusive triangular polygon in the center.

| | |
|---|---|
| 2 | Number of polygons |
| 0,4 | Inclusive, 4 vertices |
| 0., 0. | 1st vertex |
| 0., 100. | 2nd vertex |
| 100., 100. | 3rd vertex |
| 100., 0. | Last Vertex |
| 1,3 | Exclusive, 3 vertices |
| 25., 25. | 1st vertex |
| 75., 25. | 2nd vertex |
| 50., 75. | 3rd vertex |

END OF FILE

*** Note *** No blank lines may be embedded in the file.